



- (51) **International Patent Classification:**
C12Q 1/56 (2006.01)
- (21) **International Application Number:**
PCT/US2013/052101
- (22) **International Filing Date:**
25 July 2013 (25.07.2013)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
61/675,713 25 July 2012 (25.07.2012) US
- (71) **Applicant: BIOGEN IDEC MA INC.** [US/US]; 14 Cambridge Center, Cambridge, Massachusetts 02142 (US).
- (72) **Inventor: SOMMER, Jurg;** 30 Hampshire Road, Wayland, Massachusetts 01778 (US).
- (74) **Agents: STEFFE, Eric K.** et al.; Sterne, Kessler, Goldstein & Fox PLLC, 1100 New York Ave NW, Washington, District of Columbia 20005 (US).
- (81) **Designated States** (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,

BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) **Designated States** (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

- without international search report and to be republished upon receipt of that report (Rule 48.2(g))
- with sequence listing part of description (Rule 5.2(a))



(54) **Title:** BLOOD FACTOR MONITORING ASSAY AND USES THEREOF

(57) **Abstract:** The present disclosure provides methods and compositions for diagnosing and treating subject having a bleeding disorder. The disclosed methods comprise contacting a sample, e.g., a blood or plasma sample obtained from the patient, with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate. Also provided is a global hemostasis test based on the integration of clotting time (Ct) and pharmacokinetics data. The methods and compositions presented can be applied to point-of-care diagnostic systems.

BLOOD FACTOR MONITORING ASSAY AND USES THEREOF

BACKGROUND

Field of the Invention

[0001] The present invention relates generally to the field of therapeutics for hemostatic disorders.

Background Art

[0002] Hemophilia is a bleeding disorder in which blood clotting is disturbed by a lack of certain plasma clotting factors in the coagulation cascade (FIG. 1). Hemophilia A and Hemophilia B are two different types of hemophilia that are caused by deficiencies in Factor VIII (FVIII) and Factor IX, respectively.

[0003] Hemophilia A is characterized by spontaneous hemorrhage and excessive bleeding after trauma. Over time, the repeated bleeding into muscles and joints, which often begins in early childhood, results in hemophilic arthropathy and irreversible joint damage. This damage is progressive and can lead to severely limited mobility of joints, muscle atrophy and chronic pain (Rodriguez-Merchan, E.C., *Semin. Thromb. Hemost.* 29:87-96 (2003), which is herein incorporated by reference in its entirety).

[0004] Hemophilia B (also known as Christmas disease) is one of the most common inherited bleeding disorders in the world. It results in decreased in vivo and in vitro blood clotting activity and requires extensive medical monitoring throughout the life of the affected individual. In the absence of intervention, the afflicted individual will suffer from spontaneous bleeding in the joints, which produces severe pain and debilitating immobility; bleeding into muscles results in the accumulation of blood in those tissues; spontaneous bleeding in the throat and neck can cause asphyxiation if not immediately treated; renal bleeding; and severe bleeding following surgery, minor accidental injuries, or dental extractions also are prevalent.

[0005] Treatment of hemophilia is by replacement therapy targeting restoration of Factor VIII and Factor IX activity. Treatment of hemophilia A is by replacement therapy targeting restoration of FVIII activity to 1 to 5 % of normal levels to prevent spontaneous bleeding (Mannucci, P.M., et al., *N. Engl. J. Med.* 344:1773-1779 (2001), which is herein incorporated by reference in its entirety). There are plasma-derived and recombinant FVIII products available to treat bleeding episodes on-demand or to prevent bleeding episodes from occurring by treating

prophylactically. Based on the half-life of these products treatment regimens require frequent intravenous administration. Such frequent administration is painful and inconvenient.

[0006] Treatment of hemophilia B occurs by replacement of the missing clotting factor by exogenous factor concentrates highly enriched in Factor IX, but is also problematic. Generating such a concentrate from blood is fraught with technical difficulties. Purification of Factor IX from plasma (plasma derived Factor IX; pdFIX) almost exclusively yields active Factor IX. However, such purification of factor IX from plasma is very difficult because Factor IX is only present in low concentration in plasma (5 ug/mL. Andersson, Thrombosis Research 7: 451 459 (1975). Further, purification from blood requires the removal or inactivation of infectious agents such as HIV and HCV. In addition, pdFIX has a short half-life and therefore requires frequent dosing. Recombinant factor IX (rFIX) is also available, but suffers from the same short half-life and need for frequent dosing (e.g., 2-3 times per week for prophylaxis) as pdFIX. rFIX also has a lower incremental recovery (K value) compared to pdFIX, which necessitates the use of higher doses of rFIX than those for pdFIX.

[0007] Reduced mortality, prevention of joint damage and improved quality of life have been important achievements due to the development of plasma-derived and recombinant Factor VIII and Factor IX products. Prolonged protection from bleeding would represent another key advancement in the treatment of hemophilia patients. In order to address this need, recombinant Factor VIII and Factor IX proteins expressed as Fc fusions are in development. However, methods of determining appropriate dosage of these products, which have unique pharmacokinetic properties in humans have not yet been developed. Therefore, there remains a need for improved methods of treating hemophilia due to Factor VIII and Factor IX deficiencies that are more tolerable and more effective than current therapies.

[0008] Coagulation assays have gained acceptance as an important tool for management of patients being treated for coagulation disorders. These treatments are also applicable to patients on anticoagulation therapy for the prevention of clots in their blood vessels. In these assays, a sample of the patient's blood or plasma is tested for coagulation time or "clotting time" which time is related to the amount of coagulation factors in the patient's blood (or to the patient's dosage of anticoagulant in the case of patients undergoing antocoagulation therapy). Coagulation assays are also required prior to surgical procedures even for patients not suffering from bleeding disorders or on anticoagulation therapy. This is because the medical professionals need to clearly know the bleeding susceptibility before they are operated on.

[0009] A variety of coagulation test are presently in use and among the most popular is the “Activated Partial Thromboplastin Time” (aPTT) test (see FIG. 2). Blood coagulation tests have tended to be complex, and the bulk of them are performed generally in centralized clinical laboratories. Clinical or a doctor’s office visits or a regular basis to monitor coagulation factor levels can be very inconvenient and expensive. Most of apparatus and methods known for measuring coagulation time in blood samples cannot be used for home testing (see, e.g., U.S. Patent Nos. 3,695,842; 3,836,333; 4,197,734; 3,486,859; 4,797,369; 3,890,098; 4,725,554; 5,284,624; 3,951,606; 4,659,550; and 5,302,348). The disadvantages of these methods, beside cost and the challenge of operation, include the fact that most do not measure coagulation directly. The large blood volume requirements of some of these methods made them impractical for home use. Many of these methods are also limited by what kinds of coagulation tests they can perform due to the reagent chemistry requirements and the detectable signal generated.

BRIEF SUMMARY

[0010] The present disclosure provides a composition for the measurement of coagulation factor activity in a sample comprising an activated coagulation factor and a phospholipid mixture, wherein the composition is dried onto a solid substrate. The present disclose also provides a composition for the measurement of coagulation time in a sample comprising an activated coagulation factor and a phospholipid mixture, wherein the composition is dried onto a solid substrate. In some aspects, the solid substrate is selected from the group consisting of paper, plastic, glass, ceramic material, metal, and combinations thereof. In other aspects, the solid substrate is a surface on a test strip, test stick, reaction chamber, cartridge, chip, well plate, or array used in an apparatus to measure coagulation factor activity or coagulation time.

[0011] In some aspects, the coagulation factor is selected from the group consisting of FVII, FVIII, and FIX. In other aspects, the coagulation factor is a Factor VIII protein or a fragment, variant, or derivative thereof. In some aspects, the coagulation factor is a Factor IX protein or a fragment, variant, or derivative thereof. In other aspects, the activated coagulation factor is a Factor IXa protein or a fragment, variant, or derivative thereof. In some aspects, Factor IXa is present in the composition prior to drying within a range of 0.01 to 0.05 U/mL. In other aspects, the activated coagulation factor is a Factor XIa protein or a fragment, variant, or derivative thereof. In some aspects, Factor XIa is present in the composition prior to drying within a range of 0.01 to 0.05 U/mL.

[0012] In some aspects, the phospholipid mixture comprises 2 phospholipids. In other aspects, the phospholipid mixture comprises 3 phospholipids. In some aspects, the phospholipids are selected from the group consisting of phosphatidylcholine, phosphatidylserine, phosphatidylglycerol, and combinations thereof. In other aspects, the phospholipids are natural phospholipids, synthetic phospholipids, or combinations thereof. In some aspects, the phospholipid mixture comprises 70 mole-% of phosphatidylcholine and 30 mole-% of phosphatidylserine. In other aspects, the phospholipid mixture comprises 80 mole-% of phosphatidylcholine, 10 mole-% of phosphatidylserine, and 10 mole-% of phosphatidylglycerol. In some aspects, the phospholipid mixture comprises 75 mole-% of phosphatidylcholine, 20 mole-% of phosphatidylserine, and 5 mole-% of phosphatidylglycerol. In other aspects, the phospholipid mixture further comprises cholesterol. In some aspects, the cholesterol content in the phospholipid mixture is from about 1 to about 20 mole-% of cholesterol.

[0013] In some aspects, the phospholipid mixture is in vesicle form. In other aspects, the vesicles are small unilamellar vesicles. In some aspects, the composition further comprises divalent cations. In other aspects, the divalent cations are calcium ions. In some aspects, the sample is selected from the group consisting of whole blood, citrated or equivalently stabilized blood, plasma, or other fluid sample containing or suspected of containing a coagulation factor. In other cases, the sample is decalcified.

[0014] In some aspects, the measurement is carried in a point of care test system. In some aspects, the measurement is carried out in a mechanical or optical analytical system.

[0015] The present disclosure provides a composition for the measurement of the Factor VIII activity of a Factor VIII protein or a fragment, variant, or derivative thereof in a sample comprising 80% of 0.1 mg/mL Factor IXa and 20% of a phospholipid mixture comprising 75 mole-% of phosphatidylcholine, 20 mole-% of phosphatidylserine, and 5 mole-% of phosphatidylglycerol, wherein said composition is dried onto a solid substrate. Also provided is a composition for the measurement of the Factor IX activity of a Factor IX protein or a fragment, variant, or derivative thereof in a sample comprising 80% Factor X_{ia} suspension and 20% of a phospholipid mixture comprising 75 mole-% of phosphatidylcholine, 20 mole-% of phosphatidylserine, and 5 mole-% of phosphatidylglycerol, wherein said composition is dried onto a solid substrate. The exact amount of FXI_a needed varies depending on the specific activity of this reagent and is titrated for optimal amount and can include approximately 0.1 mg/mL.

[0016] The present disclosure also provides a kit for performing a measurement of coagulation factor activity or coagulation time in a sample comprising the composition of any one of claims 1 to 30 in one or more vials. Also provided is a kit for performing a measurement of coagulation factor activity or coagulation time in a sample comprising the composition of any one of claims 1 to 30 in a non-dry form in one or more vials and instructions for drying said composition onto a solid substrate. The instant disclosure also provides a sample holder for performing a blood coagulation assay, comprising a surface coated with any of the activation mixtures disclosed herein. In some aspects, the sample holder is selected from the group consisting of a test strip, a test stick, a reaction chamber, a cartridge, a chip, a well plate, and an array.

[0017] The present disclosure provides a method for determining clotting time in a patient having a bleeding disorder, comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; and, (b) measuring the time between the contacting of the activation mixture with the blood sample and the onset of clotting, thereby calculating the clotting time (Ct).

[0018] Also provided is a method of treating a patient having a bleeding disorder comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct), wherein Ct indicates whether the patient will benefit from administration of a treatment; and, (c) administering the treatment to the patient if Ct indicates that the patient will benefit from administration of the treatment. The present disclosure also provides a method of treating a patient having a bleeding disorder comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct), wherein Ct indicates whether the patient will benefit from administration of a treatment; and, (c) instructing a healthcare provider to administer the treatment to the patient if Ct indicates that the patient will benefit from administration of the treatment.

[0019] The present disclosure provides a method of optimizing a bleeding disorder treatment in a patient comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct), wherein Ct correlates with a therapeutically efficacious treatment; and, (c) administering an optimized treatment to the patient, wherein the treatment is maintained or adjusted. Also provided is a method of optimizing a bleeding disorder treatment in a patient comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct), wherein Ct correlates with a therapeutically efficacious treatment; and, (c) instructing a healthcare provider to optimize the treatment administered, wherein the treatment is maintained or adjusted.

[0020] The present disclosure also provides a method of diagnosing whether a patient is in need of treatment for a bleeding disorder comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct), wherein Ct indicates whether the patient has a bleeding disorder; and, (c) providing a treatment for the bleeding disorder if the patient is in need thereof. Also provided is a method of diagnosing whether a patient is in need of treatment for a bleeding disorder comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct), wherein Ct indicates whether the patient has a bleeding disorder; and, (c) instructing a healthcare provider to provide treatment for the bleeding disorder if the patient is in need thereof.

[0021] The present disclosure also provides a method of monitoring the efficacy of a bleeding disorder treatment administered to a patient comprising (a) contacting a sample obtained

from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); and, (c) comparing the measured Ct with the Ct obtained from a corresponding standard, wherein the standard is representative of a therapeutically efficacious treatment, and wherein a similarity between the patient's results and the standard is indicative of efficacy of the patient's current treatment; and, (d) maintaining or adjusting the patient's treatment based on the relative difference between the patient's results and the corresponding standard. Also provided is a method of monitoring the efficacy of a bleeding disorder treatment administered to a patient comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); (c) comparing the measured Ct with the Ct obtained from a corresponding standard, wherein the standard is representative of a therapeutically efficacious treatment, and wherein a similarity between the patient's results and the standard is indicative of efficacy of the patient's current treatment; and, (d) instructing a healthcare provider to maintain or adjusting the patient's treatment based on the relative difference between the patient's results and the corresponding standard.

[0022] The present disclosure also provides a method for determining a coagulation factor level in a bleeding disorder patient, comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate:

(b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); and, (c) correlating the Ct value with the level of coagulation factor in the sample. In some aspects, the correlation between Ct and coagulation factor level (%Factor) is calculated according to the formula:

$$Ct = A \times \ln(\%Factor) + B \quad \text{[Formula 1]}$$

wherein, for each coagulation factor, A is a constant value corresponding to the slope of a Ct versus coagulation factor concentration dose-response, and B is patient-specific off-set value.

[0023] The present disclosure also provides a method for determining a pharmacokinetic (PK) parameter in a bleeding disorder patient, comprising (a) contacting a sample obtained from

the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); and, (c) correlating a PK with the calculated Ct value, thereby determining the value of the PK parameter.

[0024] The present disclosure provides a method of treating a patient having a bleeding disorder comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); (c) determining a PK parameter based on Ct, wherein the PK parameter indicates that the patient will benefit from administration of the treatment; and, (d) administering the treatment to the patient if the PK parameter indicates that the patient will benefit from administration of the treatment. Also provides is a method of treating a patient having a bleeding disorder comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); (c) determining a PK parameter based on Ct, wherein the PK parameter indicates that the patient will benefit from administration of the treatment; and, (d) instructing a healthcare provider to administer the treatment to the patient if the PK parameter indicates that the patient will benefit from administration of the treatment. Also provided is method of optimizing a bleeding disorder treatment in a patient comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); (c) determining a PK parameter based on Ct, wherein the PK parameter correlates with a therapeutically efficacious treatment; and, (d) administering an optimized treatment to the patient, wherein the treatment is maintained or adjusted. The present disclosure also provides a method of optimizing a bleeding disorder treatment in a patient comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a

solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); (c) determining a PK parameter based on Ct, wherein the PK parameter correlates with a therapeutically efficacious treatment; and, (d) instructing a healthcare provider to administer an optimized treatment to the patient, wherein the therapy is maintained or adjusted.

[0025] Also provided is a method of diagnosing whether a patient is in need of treatment for a bleeding disorder comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); and, (c) determining a PK parameter based on Ct, wherein the PK parameter indicates whether the patient has a bleeding disorder; and, (d) providing treatment for the bleeding disorder if the patient is in need thereof. Also provides is a method of diagnosing whether a patient is in need of treatment for a bleeding disorder comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); and, (c) determining a PK parameter based on Ct, wherein the PK parameter indicates whether the patient has a bleeding disorder; and, (d) instructing a healthcare provider to provide therapy to treat the bleeding disorder if the patient is in need thereof.

[0026] The present disclosure also provides a method of monitoring the efficacy of a bleeding disorder treatment administered to a patient comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); and, (c) determining a PK parameter based on Ct; (d) comparing the PK parameter with the PK obtained from a corresponding standard, wherein the standard is representative of a therapeutically efficacious treatment, and wherein a similarity between the patient's results and the standard is indicative of efficacy of the patient's current treatment; and, (e) maintaining or adjusting the patient's treatment based on the relative difference between the patient's results and the corresponding standard. Also provided is

a method of monitoring the efficacy of a bleeding disorder treatment administered to a patient comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); (c) determining a PK parameter based on Ct; (d) comparing the PK parameter with the PK obtained from a corresponding standard, wherein the standard is representative of a therapeutically efficacious treatment, and wherein a similarity between the patient's results and the standard is indicative of efficacy of the patient's current treatment; and, (e) instructing a healthcare provider to maintain or adjust the patient's treatment based on the relative difference between the patient's results and the corresponding standard.

[0027] In some aspects, the PK is terminal half-life (HL). In other aspects, the PK is time to through (T). In some aspects, HL is calculated according to the formula:

$$HL = -0.693 \times (T_2 - T_1) \times A / (Ct_1 - Ct_2) \quad [\text{Formula II}]$$

wherein, for each coagulation factor, A is a constant value corresponding to the slope of a Ct versus coagulation factor concentration dose-response, T_1 and T_2 are times at which Ct is measured, and Ct_1 and Ct_2 are Ct values measured at T_1 and T_2 , respectively.

[0028] In some aspects, T is calculated according to the formula:

$$T = -1.44 \times HL / (A \times (Ct_{\text{measured}} - Ct_{\text{trough}})) \quad [\text{Formula III}]$$

wherein for each coagulation factor A is a constant value corresponding to the slope of a Ct versus coagulation factor concentration dose-response, and HL is the terminal half-life, Ct_{measured} is Ct measured at certain time point, and Ct_{trough} is patient-specific clot time at trough. In some aspects, the patient is administered a new dose of coagulation factor every T interval.

[0029] In some aspects, the sample is selected from the group consisting of whole blood, citrated or equivalently stabilized blood, plasma, or other fluid sample containing or suspected of containing a coagulation factor. In some aspects, the sample is whole blood. In other aspects, the blood is venous blood. In some aspects, the blood is fingerstick blood. In some aspects, the sample is plasma. In some aspects, the sample is frozen and thawed prior to contacting the sample with the activation mixture. In other aspects, the sample is has not been frozen and thawed prior to contacting the sample with the activation mixture. In some aspects, the sample is decalcified. In some aspects, the decalcified sample is recalcified prior to contacting the sample

with the activation mixture. In other aspects, the decalcified sample is recalcified after contacting the sample with the activation mixture.

[0030] In some aspects, the sample further comprises an added purified coagulation factor. In other aspects, the sample further comprises an added inhibitor. In some aspects, the purified coagulation factor is selected from the group consisting of Factors II, Factor VII, Factor VIII, Factor IX, Factor X, Factor XI, Factor XII, Factor XIII, Fibrinogen, vWF, Tissue Factor, and combinations thereof. In some aspects, the inhibitor is selected from the group consisting of CTI, aprotinin, ϵ -aminocaproic acid (EACA), D-Phenylalanyl-L-prolyl-L-arginine chloromethyl ketone-Factor VIIa (FPRCK-FVIIa), anti-coagulation factor monoclonal antibodies, and combinations thereof. In some aspects, the sample is diluted with substrate sample. In specific aspects, one part of sample is diluted with three parts of substrate sample.

[0031] In some aspects, the activated coagulation factor is a Factor IXa protein or a fragment, variant, or derivative thereof. In some aspects, Factor IXa is present in the composition prior to drying within a range of 0.01 to 0.05 U/mL. In other aspects, the activated coagulation factor is a Factor XIa protein or a fragment, variant, or derivative thereof. In some aspects, Factor XIa is present in the composition prior to drying within a range of 0.01 to 0.05 U/mL. In some aspects, the phospholipid mixture comprises 2 phospholipids. In some aspects, the phospholipid mixture comprises 3 phospholipids. In other aspects, the phospholipids in the phospholipid mixture are selected from the group consisting of phosphatidylcholine, phosphatidylserine, phosphatidylglycerol, and combinations thereof. In some aspects, the phospholipids are natural phospholipids, synthetic phospholipids, or combinations thereof. In some aspects, the phospholipid mixture comprises 70 mole-% of phosphatidylcholine and 30 mole-% of phosphatidylserine. In other aspects, the phospholipid mixture comprises 80 mole-% of phosphatidylcholine, 10 mole-% of phosphatidylserine, and 10 mole-% of phosphatidylglycerol. In other aspects, the phospholipid mixture comprises 75 mole-% of phosphatidylcholine, 20 mole-% of phosphatidylserine, and 5 mole-% of phosphatidylglycerol. In some aspects, the phospholipid mixture further comprises cholesterol. In some aspects, the cholesterol content in the phospholipid mixture is from about 1 to about 20 mole-% of cholesterol. In some aspects, the phospholipid mixture is in lipid vesicle form. In some aspects, the lipid vesicles are small unilamellar vesicles. In some aspects, the activation mixture further comprises divalent cations. In other aspects, the divalent cations are calcium ions.

[0032] In some aspects, the activation mixture reacts with a coagulation factor selected from the group consisting of Factor VII, Factor VIII, and Factor IX. In other aspects, the Factor VIII coagulation factor is a Factor VIII protein or a fragment, variant, or derivative thereof. In some aspects, the Factor IX coagulation factor is a Factor IX protein or a fragment, variant, or derivative thereof. In other aspects, the Factor VIII coagulation factor is a chimeric Factor VIII-Fc fusion protein. In some aspects, the Factor IX coagulation factor is a chimeric Factor IX-Fc fusion protein. In other aspects, the Fc portion of the chimeric Factor VIII or Factor IX protein comprises a human Fc domain. In some aspects, the chimeric Factor VIII protein comprises a B-domain deleted Factor VIII. In specific aspects, the chimeric Factor VIII protein comprises SEQ ID NO:6. In other aspects, the chimeric Factor VIII protein comprises SEQ ID NO:2. In some aspects, the chimeric Factor IX protein comprises SEQ ID NO: 13.

[0033] In some aspects, the solid substrate is selected from the group consisting of paper, plastic, glass, ceramic material, metal, and combinations thereof. In other aspects, the solid substrate is a surface on a test strip, test stick, reaction chamber, cartridge, chip, well plate, or array used in an apparatus to measure coagulation factor activity or coagulation time. In some aspects, the patient has not yet been treated with a coagulation factor. In some aspects, the patient has received prior coagulation factor treatment, but the treatment has been discontinued for a time period sufficient to deplete the coagulation factor treatment from the patient's blood. In some aspects, the measurement is carried in a point of care test system. In another aspect, the measurement is carried out in a mechanical or optical analytical system.

BRIEF DESCRIPTION OF THE DRAWINGS/FIGURES

[0034] FIG. 1 shows a schematic representation of the coagulation cascade.

[0035] FIG. 2 shows an overview of one stage assay (aPTT).

[0036] FIG. 3 shows clotting time for hemophilia A donor plasma spiked with rFVIII_h measured using the Standard FMS Factor VIII assay. FIXa/phospholipid was used as activator mixture. Samples consisted of 12 μ L of re-calcified plasma applied directly (without preincubation) to the test bed.

[0037] FIG. 4 shows clotting time for hemophilia B donor plasma spiked with rFIX_h measured using the Standard FMS Factor IX assay. FXIa/phospholipid was used as activator mixture. Samples consisted of 12 μ L of re-calcified plasma applied directly (without preincubation) to the test bed.

[0038] FIG. 5A shows clotting time determined using the Standard FMS Factor VIII assay using Phospholipid Blend 2 in the activated coagulation factor-phospholipid complex. Samples BD1-003, BD1-002, BD1-001 and BD1-005 were collected from 4 hemophilia A subjects and each sample was spiked with 6 levels of rFVIII Fc (100%, 50%, 25%, 12.5%, 6.3% and 3.1%).

[0039] FIG. 5B shows clotting time determined using the Standard FMS Factor VIII assay using Phospholipid Blend 8 in the activated coagulation factor-phospholipid complex. Samples BD1-003, BD1-002, BD1-001 and BD1-005 were collected from 4 hemophilia A subjects and each sample was spiked with 6 levels of rFVIII Fc (100%, 50%, 25%, 12.5%, 6.3% and 3.1%).

[0040] FIG. 6A shows a comparison of clotting time determined using the Standard FMS Factor VIII assay (Standard Method) and Alternate FMS Factor VIII assay (Alternate Method 3). Samples contained 12 μ L of re-calcified plasma mixed 1:3 with substrate plasma (Factor VIII deficient plasma supplemented with defined levels of rFVIII Fc). Factor IXa/phospholipids complex was used as activator.

[0041] FIG. 6B shows clotting time measured using the Alternate FMS Factor IX assay (Alternate Method 9.8). Samples contained 12 μ L of re-calcified plasma mixed 1:3 with substrate plasma (Factor IX deficient plasma supplemented with defined levels of rFIX Fc). Factor XIa/phospholipids complex was used as activator.

[0042] FIG. 7A shows the effect of a single plasma freeze-thaw cycle on Alternate FMS Factor IX assay performance. Samples contained 12 μ L of re-calcified plasma mixed 1:3 with substrate plasma (Factor IX deficient plasma supplemented with defined levels of rFIX Fc).

[0043] FIG. 7B shows clotting times corresponding to fresh plasma samples, and plasma subjected to a single plasma freeze-thaw cycle as measured using the Alternate FMS Factor VIII assay. Samples contained 12 μ L of re-calcified plasma mixed 1:3 with substrate plasma (Factor VIII deficient plasma supplemented with defined levels of rFVIII Fc).

[0044] FIG. 8A shows the correlation between spiked rFVIII Fc levels measured using the Alternate FMS Factor VIII assay and rFVIII Fc levels measured by MLA. Citrated plasma samples from 14 hemophilia A donor were collected at 3 sites by 3 different methodologies, and spiked with varying levels of rFVIII Fc prior to being assayed using the Alternate FMS Factor VIII assay or MLA.

[0045] FIG. 8B shows the correlation between spiked rFXFc levels measured using the Alternate FMS FIX assays and rFIXFc levels measured by MLA. Citrated plasma samples from 9 hemophilia B donor were collected at 3 sites using 3 different methodologies, and spiked with varying levels of rFIXFc prior to being assayed using Alternate FMS FIX assay or MLA.

[0046] FIG. 9A shows clotting time results obtained by applying the Standard FMS FVIII assay to pre-dose whole blood samples obtained from two hemophilia A subjects (samples designated BD1-003 and BD1-005, respectively) spiked with increasing concentration of rFVIII Fc (0 IU/dl to 200 IU/dL).

[0047] FIG. 9B shows clotting time results obtained by applying the Alternate FMS FVIII assay to pre-dose whole blood samples obtained from two hemophilia A subjects (samples designated BD1-003 and BD1-005, respectively) spiked with increasing concentration of rFVIII Fc (0 IU/dl to 200 IU/dL).

[0048] FIGS. 10A, 10B and 10C show clotting times obtained using MLA assay. Samples were frozen plasma retains prepared from the samples spiked with various concentration of rFVIII Fc. FIG. 10A shows results corresponding to Factor VIII calibration plasma and rFVIII Fc samples. FIG. 10B shows results corresponding to pre-dose samples obtained from two hemophilia A subjects (samples designated BD1-003 and BD1-005, respectively) spiked with increasing concentration of rFVIII Fc. FIG. 10C shows results corresponding to post-dose samples obtained from two hemophilia A subjects (samples designated BD1-003 and BD1-005, respectively) spiked with increasing concentration of rFVIII Fc.

[0049] FIGS. 11A and 11B show, respectively, Standard FMS Factor VIII assay measurements conducted on frozen plasma retains of pre-dose (FIG. 11A) and post-dose (FIG. 11B) samples obtained from two hemophilia A subjects (samples designated BD1-003 and BD1-005, respectively) spiked with increasing concentration of rFVIII Fc.

[0050] FIGS. 12A and 12B show, respectively, Alternate FMS Factor VIII assay measurements conducted on frozen plasma retains of pre-dose (FIG. 11A) and post-dose (FIG. 11B) samples obtained from two hemophilia A subjects (samples designated BD1-003 and BD1-005, respectively) spiked with increasing concentration of rFVIII Fc.

[0051] FIG. 13 shows the correlation between whole blood clotting and plasma clotting time measurements performed using the Alternate FMS FVIII assay.

[0052] FIG. 14A compares Alternate FMS Factor VIII assay clotting times for plasma and whole blood samples obtained from two patients (BD1-002 and BD1-004). FIG. 14B shows

the correlation between whole blood clotting time and plasma clotting time measurements performed using the Alternate FMS FVIII assay. Pre-dose blood samples were spiked with increasing concentrations of rFVIII_{Fc} (0 IU/dL -- 200 IU/dL).

[0053] FIG. 15A compares Alternate FMS Factor IX assay clotting times for plasma and whole blood samples. FIG. 15B shows the correlation between whole blood clotting time and plasma clotting time using the Alternate FMS FIX assay. Pre-dose blood samples were spiked with increasing concentration of rFIX_{Fc} (0 IU/dL – 200 IU/dL).

[0054] FIG. 16 shows the variability between meters assaying a single FVIII deficient plasma sample spiked to 100% (triangles) and 3% (circles) rFVIII_{Fc} in duplicate on 16 research meters using the Alternate FMS FVIII assay.

[0055] FIG. 17 provides a diagram showing the correlation between coagulation factor concentration (%Factor) and clotting time (Ct) from FMS assays, and the application of such correlation to a point-of-care device.

[0056] FIG. 18 provides a diagram showing the calculation of terminal half-life from data obtained from FMS assays and its integration with pharmacokinetics data to calculate time to trough and determine patient-specific doses and interval between doses.

DETAILED DESCRIPTION

[0057] The present disclosure provides methods and compositions for diagnosing and treating subject having a bleeding disorder. The disclosed methods comprise contacting a sample, *e.g.*, a blood sample or a plasma sample obtained from the patient, with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate. In some aspects, the time between the contacting of the activation mixture with the blood sample and the onset of clotting, *i.e.*, the clotting time (Ct), is used to calculate pharmacokinetic parameters which in turn can be used to commence, modify, or cease treatment with coagulation factors. Certain FVIII and FIX polypeptides for use in the methods provided herein are described in International Application No. PCT/US2010/059136, filed December 6, 2010, and in International Application No. PCT/US2011/043569, filed July 11, 2011, each of which is herein incorporated by reference in its entirety.

I. Definitions

[0058] It must be noted that, as used in this specification and the appended claims, the singular forms "a", "an" and "the" include plural referents unless the context clearly dictates otherwise. The terms "a" (or "an"), as well as the terms "one or more," and "at least one" can be used interchangeably herein.

[0059] Furthermore, "and/or" where used herein is to be taken as specific disclosure of each of the two specified features or components with or without the other. Thus, the term "and/or" as used in a phrase such as "A and/or B" herein is intended to include "A and B," "A or B," "A" (alone), and "B" (alone). Likewise, the term "and/or" as used in a phrase such as "A, B, and/or C" is intended to encompass each of the following aspects: A, B, and C; A, B, or C; A or C; A or B; B or C; A and C; A and B; B and C; A (alone); B (alone); and C (alone).

[0060] It is understood that wherever aspects are described herein with the language "comprising," otherwise analogous aspects described in terms of "consisting of" and/or "consisting essentially of" are also provided.

[0061] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure is related. For example, the Concise Dictionary of Biomedicine and Molecular Biology, Juo, Pei-Show, 2nd ed., 2002, CRC Press; The Dictionary of Cell and Molecular Biology, 3rd ed., 1999, Academic Press; and the Oxford Dictionary Of Biochemistry And Molecular Biology, Revised, 2000, Oxford University Press, provide one of skill with a general dictionary of many of the terms used in this disclosure.

[0062] Units, prefixes, and symbols are denoted in their Système International de Unites (SI) accepted form. Numeric ranges are inclusive of the numbers defining the range. Unless otherwise indicated, amino acid sequences are written left to right in amino to carboxy orientation. The headings provided herein are not limitations of the various aspects of the disclosure, which can be had by reference to the specification as a whole. Accordingly, the terms defined immediately below are more fully defined by reference to the specification in its entirety.

[0063] "Administering," as used herein, refers to giving a pharmaceutically acceptable amount of a therapeutic agent such as a coagulation factor, *e.g.*, Factor VIII or Factor IX polypeptide, to a subject via a pharmaceutically acceptable route. Routes of administration include intravenous, *e.g.*, intravenous injection and intravenous infusion, *e.g.*, via central venous access. Additional routes of administration include subcutaneous, intramuscular, oral, nasal, and pulmonary administration. In some aspects, the administration is subcutaneous. Coagulation

factors, *e.g.*, Factor VIII and Factor IX, including fragments, variants, derivatives, chimeric polypeptides, or hybrid polypeptide can be administered as part of a pharmaceutical composition comprising at least one excipient. The term administering also refers to giving any other therapeutic agent or prophylactic agent (*e.g.*, a small molecule) that can be given in a pharmaceutically acceptable amount to a subject having a coagulation-related disorder via a pharmaceutically acceptable route.

[0064] The term "sequence" as used to refer to a protein sequence, a peptide sequence, a polypeptide sequence, or an amino acid sequence means a linear representation of the amino acid constituents in the polypeptide in an amino-terminal to carboxyl-terminal direction in which residues that neighbor each other in the representation are contiguous in the primary structure of the polypeptide.

[0065] By a "protein" or "polypeptide" is meant any sequence of two or more amino acids linearly linked by amide bonds (peptide bonds) regardless of length, post-translation modification, or function. As used herein, the term "polypeptide" is intended to encompass a singular "polypeptide" as well as plural "polypeptides." "Polypeptide," "peptide," and "protein" are used interchangeably herein. Thus, peptides, dipeptides, tripeptides, or oligopeptides are included within the definition of "polypeptide," and the term "polypeptide" can be used instead of, or interchangeably with any of these terms. The term "polypeptide" is also intended to refer to the products of post-expression modifications of the polypeptide, including without limitation glycosylation, acetylation, phosphorylation, amidation, derivatization by known protecting/blocking groups, proteolytic cleavage, or modification by non-naturally occurring amino acids. A polypeptide can be derived from a natural biological source or produced by recombinant technology, but is not necessarily translated from a designated nucleic acid sequence. A polypeptide can be generated in any manner, including by chemical synthesis. Also included as polypeptides of the present disclosure are fragments, derivatives, analogs, or variants of the foregoing polypeptides, and any combination thereof.

[0066] The term "fragment" when referring to polypeptides and proteins, *e.g.*, coagulation factors such as Factor VIII or Factor IX, include any polypeptides or proteins which retain at least some of the properties of the reference polypeptide or protein. *E.g.*, in the case of procoagulant polypeptides such as coagulation factors and procoagulant peptides, the term fragment would refer to any polypeptides or proteins which retain at least some of the

procoagulant activity of the reference polypeptide or protein. Fragments of polypeptides include proteolytic fragments, as well as deletion fragments.

[0067] The term "variant" as used herein refers to a polypeptide sequence that differs from that of a parent polypeptide sequence by virtue of at least one amino acid modification. Variants can occur naturally or be non-naturally occurring. Non-naturally occurring variants can be produced using art-known mutagenesis techniques. Variant polypeptides can comprise conservative or non-conservative amino acid substitutions, deletions, or additions.

[0068] "Derivatives" of polypeptides or proteins of the present disclosure are polypeptides or proteins which have been altered so as to exhibit additional features not found on the native polypeptide or protein. Also included as "derivatives" are those peptides that contain one or more naturally occurring amino acid derivatives of the twenty standard amino acids. A polypeptide or amino acid sequence "derived from" a designated polypeptide or protein refers to the origin of the polypeptide. Preferably, the polypeptide or amino acid sequence which is derived from a particular sequence has an amino acid sequence that is essentially identical to that sequence or a portion thereof, wherein the portion consists of at least 10-20 amino acids, preferably at least 20-30 amino acids, more preferably at least 30-50 amino acids, or which is otherwise identifiable to one of ordinary skill in the art as having its origin in the sequence.

[0069] Polypeptides derived from another peptide can have one or more mutations relative to the starting polypeptide, *e.g.*, one or more amino acid residues which have been substituted with another amino acid residue or which has one or more amino acid residue insertions or deletions. Preferably, the polypeptide comprises an amino acid sequence which is not naturally occurring. Such variants necessarily have less than 100% sequence identity or similarity with the starting polypeptide. In one aspect, the variant will have an amino acid sequence from about 75% to less than 100% amino acid sequence identity or similarity with the amino acid sequence of the starting polypeptide, more preferably from about 80% to less than 100%, more preferably from about 85% to less than 100%, more preferably from about 90% to less than 100% (*e.g.*, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%) and most preferably from about 95% to less than 100%, *e.g.*, over the length of the variant molecule. In one aspect, there is one amino acid difference between a starting polypeptide sequence and the sequence derived therefrom. Identity or similarity with respect to this sequence is defined herein as the percentage of amino acid residues in the candidate sequence that are identical (*i.e.* same residue) with the

starting amino acid residues, after aligning the sequences and introducing gaps, if necessary, to achieve the maximum percent sequence identity.

[0070] A polypeptide which is "isolated" is a polypeptide which is in a form not found in nature. Isolated polypeptides include those which have been purified to a degree that they are no longer in a form in which they are found in nature. In some aspects, a polypeptide which is isolated is substantially pure.

[0071] A "recombinant" polypeptide or protein refers to a polypeptide or protein produced via recombinant DNA technology. Recombinantly produced polypeptides and proteins expressed in host cells are considered isolated for the purpose of the invention, as are native or recombinant polypeptides which have been separated, fractionated, or partially or substantially purified by any suitable technique. The polypeptides disclosed herein, *e.g.*, clotting factors, can be recombinantly produced using methods known in the art. Alternatively, proteins and peptides disclosed herein can be chemically synthesized.

[0072] A "conservative amino acid substitution" is one in which the amino acid residue is replaced with an amino acid residue having a similar side chain. Families of amino acid residues having similar side chains have been defined in the art, including basic side chains (*e.g.*, Lys, Arg, His), acidic side chains (*e.g.*, Asp, Glu), uncharged polar side chains (*e.g.*, Gly, Asn, Gln, Ser, Thr, Tyr, Cys), nonpolar side chains (*e.g.*, Ala, Val, Leu, Ile, Pro, Phe, Met, Trp), beta-branched side chains (*e.g.*, Thr, Val, Ile) and aromatic side chains (*e.g.*, Tyr, Phe, Trp, His). Thus, if an amino acid in a polypeptide is replaced with another amino acid from the same side chain family, the substitution is considered to be conservative. In another aspect, a string of amino acids can be conservatively replaced with a structurally similar string that differs in order and/or composition of side chain family members.

[0073] Non-conservative substitutions include those in which (i) a residue having an electropositive side chain (*e.g.*, Arg, His or Lys) is substituted for, or by, an electronegative residue (*e.g.*, Glu or Asp), (ii) a hydrophilic residue (*e.g.*, Ser or Thr) is substituted for, or by, a hydrophobic residue (*e.g.*, Ala, Leu, He, Phe or Val), (iii) a cysteine or proline is substituted for, or by, any other residue, or (iv) a residue having a bulky hydrophobic or aromatic side chain (*e.g.*, Val, He, Phe or Trp) is substituted for, or by, one having a smaller side chain (*e.g.*, Ala, Ser) or no side chain (*e.g.*, Gly).

[0074] The term "percent sequence identity" between two polynucleotide or polypeptide sequences refers to the number of identical matched positions shared by the sequences over a

comparison window, taking into account additions or deletions (*i.e.*, gaps) that must be introduced for optimal alignment of the two sequences. A matched position is any position where an identical nucleotide or amino acid is presented in both the target and reference sequence. Gaps presented in the target sequence are not counted since gaps are not nucleotides or amino acids. Likewise, gaps presented in the reference sequence are not counted since target sequence nucleotides or amino acids are counted, not nucleotides or amino acids from the reference sequence.

[0075] The percentage of sequence identity is calculated by determining the number of positions at which the identical amino-acid residue or nucleic acid base occurs in both sequences to yield the number of matched positions, dividing the number of matched positions by the total number of positions in the window of comparison and multiplying the result by 100 to yield the percentage of sequence identity. The comparison of sequences and determination of percent sequence identity between two sequences can be accomplished using readily available software both for online use and for download. Suitable software programs are available from various sources, and for alignment of both protein and nucleotide sequences. One suitable program to determine percent sequence identity is bl2seq, part of the BLAST suite of program available from the U.S. government's National Center for Biotechnology Information BLAST web site (blast.ncbi.nlm.nih.gov). Bl2seq performs a comparison between two sequences using either the BLASTN or BLASTP algorithm. BLASTN is used to compare nucleic acid sequences, while BLASTP is used to compare amino acid sequences. Other suitable programs are, *e.g.*, Needle, Stretcher, Water, or Matcher, part of the EMBOSS suite of bioinformatics programs and also available from the European Bioinformatics Institute (EBI) at www.ebi.ac.uk/Tools/psa.

[0076] Different regions within a single polynucleotide or polypeptide target sequence that aligns with a polynucleotide or polypeptide reference sequence can each have their own percent sequence identity. It is noted that the percent sequence identity value is rounded to the nearest tenth. For example, 80.11, 80.12, 80.13, and 80.14 are rounded down to 80.1, while 80.15, 80.16, 80.17, 80.18, and 80.19 are rounded up to 80.2. It also is noted that the length value will always be an integer.

[0077] In certain aspects, the percentage identity "X" of a first amino acid sequence to a second sequence amino acid is calculated as $100 \times (Y/Z)$, where Y is the number of amino acid residues scored as identical matches in the alignment of the first and second sequences (as aligned by visual inspection or a particular sequence alignment program) and Z is the total

number of residues in the second sequence. If the length of a first sequence is longer than the second sequence, the percent identity of the first sequence to the second sequence will be higher than the percent identity of the second sequence to the first sequence.

[0078] One skilled in the art will appreciate that the generation of a sequence alignment for the calculation of a percent sequence identity is not limited to binary sequence-sequence comparisons exclusively driven by primary sequence data. Sequence alignments can be derived from multiple sequence alignments. One suitable program to generate multiple sequence alignments is ClustalW2, available from www.clustal.org. Another suitable program is MUSCLE, available from www.drive5.com/muscle/. ClustalW2 and MUSCLE are alternatively available, *e.g.*, from the EBI.

[0079] It will also be appreciated that sequence alignments can be generated by integrating sequence data with data from heterogeneous sources such as structural data (*e.g.*, crystallographic protein structures), functional data (*e.g.*, location of mutations), or phylogenetic data. A suitable program that integrates heterogeneous data to generate a multiple sequence alignment is T-Coffee, available at www.tcoffee.org, and alternatively available, *e.g.*, from the EBI. It will also be appreciated that the final alignment used to calculate percent sequence identity can be curated either automatically or manually.

[0080] "Polynucleotide" and "nucleic acid" are used interchangeably and refer to a polymeric compound comprised of covalently linked nucleotide residues. Polynucleotides can be DNA, cDNA, RNA, single stranded, or double stranded, vectors, plasmids, phage, or viruses. Polynucleotides include those in Sequence Table 1, which encode the polypeptides of Sequence Table 2 (see Sequence Table 1). Polynucleotides also include fragments of the polynucleotides of Table 1, *e.g.*, those that encode fragments of the polypeptides of Table 2, such as Factor VIII, Factor IX, Fc, signal sequence, propeptide, 6His and other fragments of the polypeptides of Sequence Table 2.

[0081] The terms "subject" and "patient" are used interchangeably and refer to a human or a non-human mammal, for whom diagnosis, prognosis, or therapy of a bleeding disorder is desired. Non-human mammals include mice, dogs, primates, bears, cats, horses, cows, pigs, and other domestic animals and small animals. Subjects also include pediatric humans. Pediatric human subjects are birth to 20 years, *e.g.*, birth to 18 years, birth to 16 years, birth to 15 years, birth to 12 years, birth to 11 years, birth to 6 years, birth to 5 years, birth to 2 years, or 2 to 11 years of age. In some aspects of the present disclosure, a subject is a naïve subject. A naïve

subject is a subject that has not been administered a treatment for a bleeding disorder. In some aspects, a naïve subject has not been treated with prior to being diagnosed with having a bleeding disorder.

[0082] The methods disclosed herein can be practiced on a subject in need of control or prevention of bleeding, bleeding episodes, or hemophilia disorders. Such subjects include those in need of control or prevention of bleeding in minor hemorrhage, hemarthroses, superficial muscle hemorrhage, soft tissue hemorrhage, moderate hemorrhage, intramuscle or soft tissue hemorrhage with dissection, mucous membrane hemorrhage, hematuria, major hemorrhage, hemorrhage of the pharynx, hemorrhage of the retropharynx, hemorrhage of the retroperitoneum, hemorrhage of the central nervous system, bruises, cuts, scrapes, joint hemorrhage, nose bleed, mouth bleed, gum bleed, intracranial bleeding, intraperitoneal bleeding, minor spontaneous hemorrhage, bleeding after major trauma, moderate skin bruising, or spontaneous hemorrhage into joints, muscles, internal organs or the brain. Such subjects also include those need of peri-operative management, such as management of bleeding associated with surgery or dental extraction.

[0083] The term "bleeding disease or disorder," as used herein, means a genetically inherited or acquired condition characterized by a tendency to hemorrhage, either spontaneously or as a result of trauma, due to an impaired ability or inability to form a fibrin clot. Examples of such disorders include hemophilias. The three main forms are hemophilia A (factor VIII deficiency), hemophilia B (factor IX deficiency or "Christmas disease") and hemophilia C (factor XI deficiency, mild bleeding tendency). Other hemostatic disorders include, *e.g.*, von Willebrand disease, Factor XI deficiency (PTA deficiency), Factor XII deficiency, deficiencies or structural abnormalities in fibrinogen, prothrombin, Factor V, Factor VII, Factor X or factor XIII, Bernard-Soulier syndrome, which is a defect or deficiency in GPIIb. GPIIb, the receptor for vWF, can be defective and lead to lack of primary clot formation (primary hemostasis) and increased bleeding tendency), and thrombasthenia of Glanzman and Naegeli (Glanzmann thrombasthenia). In liver failure (acute and chronic forms), there is insufficient production of coagulation factors by the liver; this can increase bleeding risk.

[0084] Bleeding disease or disorder can require on-demand treatment or prophylactic treatment. "On-demand treatment," as used herein, means treatment that is intended to take place over a short course of time and is in response to an existing condition, such as a bleeding episode, or a perceived short term need such as planned surgery. Conditions that can require on-demand

treatment include a bleeding episode, hemarthrosis, muscle bleed, oral bleed, hemorrhage, hemorrhage into muscles, oral hemorrhage, trauma, trauma capitis, gastrointestinal bleeding, intracranial hemorrhage, intra-abdominal hemorrhage, intrathoracic hemorrhage, bone fracture, central nervous system bleeding, bleeding in the retropharyngeal space, bleeding in the retroperitoneal space, or bleeding in the iliopsoas sheath. Bleeding episodes other than these are also included. The subject can be in need of surgical prophylaxis, peri-operative management, or treatment for surgery. Such surgeries include minor surgery, major surgery, tooth extraction, tonsillectomy, other dental/thoraco-facial surgeries, inguinal herniotomy, synovectomy, total knee replacement, other joint replacement, craniotomy, osteosynthesis, trauma surgery, intracranial surgery, intra-abdominal surgery, intrathoracic surgery. Surgeries other than these are also included.

[0085] Additional conditions that can require on-demand treatment include minor hemorrhage, hemarthroses, superficial muscle hemorrhage, soft tissue hemorrhage, moderate hemorrhage, intramuscle or soft tissue hemorrhage with dissection, mucous membrane hemorrhage, hematuria, major hemorrhage, hemorrhage of the pharynx, hemorrhage of the retropharynx, hemorrhage of the retroperitonium, hemorrhage of the central nervous system, bruises, cuts, scrapes, joint hemorrhage, nose bleed, mouth bleed, gum bleed, intracranial bleeding, intraperitoneal bleeding, minor spontaneous hemorrhage, bleeding after major trauma, moderate skin bruising, or spontaneous hemorrhage into joints, muscles, internal organs or the brain. Additional reasons for on-demand treatment include the need for peri-operative management for surgery or dental extraction, major surgery, extensive oral surgery, urologic surgery, hernia surgery, orthopedic surgery such as replacement of knee, hip, or other major joint.

[0086] The terms "prophylactic treatment" or "prophylaxis" as used herein, mean administering a procoagulant compound, *e.g.*, a clotting factor, fragment, variant, derivative, chimeric peptide, or hybrid peptide thereof, to a subject over a course of time to increase the level of activity in a subject's plasma. Preferably, the increased level is sufficient to decrease the incidence of spontaneous bleeding or to prevent bleeding, *e.g.*, in the event of an unforeseen injury. Preferably, during prophylactic treatment, the plasma protein level in the subject does not fall below the baseline level for that subject, or below the level that characterizes severe hemophilia.

[0087] The term "about" is used herein to mean approximately, roughly, around, or in the regions of. When the term "about" is used in conjunction with a numerical range, it modifies that range by extending the boundaries above and below the numerical values set forth. Thus, "about 10-20" means "about 10 to about 20." In general, the term "about" is used herein to modify a numerical value above and below the stated value by a variance of 10 percent, up or down (higher or lower).

[0088] The term "pharmacokinetic parameters" or "PK parameters" as used herein refers to those constant and variable terms that are related to the disposition of a pharmacologically active agent, e.g., a coagulation factor, within a subject and includes for example volume of distribution, total clearance, metabolic clearance, bioavailability, intrinsic clearance, mean residence time, partitioning coefficients between tissues and blood, elimination rates, half-life, terminal half-life, time to trough, as well as other parameters known in the art. PK parameters can be based, e.g., on protein level or activity level. In addition, certain PK parameters can be based on model predicted data, on observed data, or on combinations of model and observed data.

[0089] As used herein, the term "clotting factor," refers to molecules, fragment, derivatives, or analogs thereof, naturally occurring or recombinantly produced, which prevent or decrease the duration of a bleeding episode in a subject. In other words, it means molecules having pro-clotting or pro-coagulant activity, *i.e.*, are responsible for the conversion of fibrinogen into a mesh of insoluble fibrin causing the blood to coagulate or clot. The term "clotting factor" as used herein also encompasses synthetic peptides with procoagulant activity.

[0090] The term "clotting time" as used herein, refers to the time period elapsed from the time when the sample is contacted with the activating mixture until the time when the sample clots.

[0091] "Half-Life" as used herein, refers to a biological half-life of a particular therapeutic agent *in vivo*. Terminal half-life can be represented by the time required for half the quantity administered to a subject to be cleared from the circulation and/or other tissues in the subject. When a clearance curve of a given polypeptide is constructed as a function of time, the curve is usually biphasic with a rapid α -phase and longer β -phase. The α -phase typically represents an equilibration of the administered chimeric polypeptide between the intra- and extra-vascular space and is, in part, determined by the size of the polypeptide. The β -phase typically represents the catabolism of the polypeptide in the intravascular space.

[0092] The term "terminal plasma half-life" or "terminal half-life" refers to the time required to divide the plasma concentration by two after reaching pseudo-equilibrium. The terminal half-life is especially relevant to multiple dosing regimens, because it controls the degree of therapeutic agent accumulation, concentration fluctuations, and the time taken to reach equilibrium.

[0093] "Trough," as used herein, is the lowest plasma activity level reached after administering a dose of a pharmacologically active agent, *e.g.*, a clotting factor such as Factor VIII or Factor IX, a fragment, a derivative or an analog thereof, before the next dose is administered, if any. Accordingly, "time to trough" (T) is the time at which the lowest plasma activity level is reached after administering a pharmacologically active agent before the next dose is administered.

[0094] The term "sample" as used herein includes any biological fluid or issue, such as whole blood or serum, obtained from a subject which contains or is suspected to contain a blood coagulation factor. In some specific aspects, that sample is blood or a fraction thereof, muscle, skin, or a combination thereof. Samples can be obtained by any means known in the art.

[0095] In order to apply the methods and systems of the disclosure, samples from a patient can be obtained before or after the administration of a therapy to treat a bleeding disorder. In some cases, successive samples can be obtained from the patient after therapy has commenced or after therapy has ceased. Samples can, for example, be requested by a healthcare provider (*e.g.*, a doctor) or healthcare benefits provider, obtained and/or processed by the same or a different healthcare provider (*e.g.*, a nurse, a hospital) or a clinical laboratory, and after processing, the results can be forwarded to yet another healthcare provider, healthcare benefits provider or the patient. Similarly, the measuring/determination of clotting times and/or PK parameters derived from clotting times, comparisons between clotting times and/or PK parameters derived from clotting times, evaluation of the clotting times and/or PK parameters derived from clotting time, and treatment decisions can be performed by one or more healthcare providers, healthcare benefits providers, and/or clinical laboratories.

[0096] As used herein, the term "healthcare provider" refers to individuals or institutions which directly interact and administer to living subjects, *e.g.*, human patients. Non-limiting examples of healthcare providers include doctors, nurses, technicians, therapist, pharmacists, counselors, alternative medicine practitioners, medical facilities, doctor's offices, hospitals, emergency rooms, clinics, urgent care centers, alternative medicine clinics/facilities, and any

other entity providing general and/or specialized treatment, assessment, maintenance, therapy, medication, and/or advice relating to all, or any portion of, a patient's state of health, including but not limited to general medical, specialized medical, surgical, and/or any other type of treatment, assessment, maintenance, therapy, medication and/or advice.

[0097] As used herein, the term "clinical laboratory" refers to a facility for the examination or processing of materials derived from a living subject, e.g., a human being. Non-limiting examples of processing include biological, biochemical, serological, chemical, immunohematological, hematological, biophysical, cytological, pathological, genetic, or other examination of materials derived from the human body for the purpose of providing information, e.g., for the diagnosis, prevention, or treatment of any disease or impairment of, or the assessment of the health of living subjects, e.g., human beings. These examinations can also include procedures to collect or otherwise obtain a sample, prepare, determine, measure, or otherwise describe the presence or absence of various substances in the body of a living subject, e.g., a human being, or a sample obtained from the body of a living subject, e.g., a human being.

[0098] As used herein, the term "healthcare benefits provider" encompasses individual parties, organizations, or groups providing, presenting, offering, paying for in whole or in part, or being otherwise associated with giving a patient access to one or more healthcare benefits, benefit plans, health insurance, and/or healthcare expense account programs.

[0099] In some aspects, a healthcare provider can administer or instruct another healthcare provider to administer a therapy to treat a bleeding disease or disorder. A healthcare provider can implement or instruct another healthcare provider or patient to perform the following actions: obtain a sample, process a sample, submit a sample, receive a sample, transfer a sample, analyze or measure a sample, quantify a sample, provide the results obtained after analyzing/measuring/quantifying a sample, receive the results obtained after analyzing/measuring/quantifying a sample, compare/score the results obtained after analyzing/measuring/quantifying one or more samples, provide the comparison/score from one or more samples, obtain the comparison/score from one or more samples, administer a therapy or therapeutic agent (e.g., a clotting factor such as a Factor VIII or Factor IX polypeptide), commence the administration of a therapy, cease the administration of a therapy, continue the administration of a therapy, temporarily interrupt the administration of a therapy, increase the amount of an administered therapeutic agent, decrease the amount of an administered therapeutic agent, continue the administration of an amount of a therapeutic agent, increase the frequency of

administration of a therapeutic agent, decrease the frequency of administration of a therapeutic agent, maintain the same dosing frequency on a therapeutic agent, replace a therapy or therapeutic agent by at least another therapy or therapeutic agent, combine a therapy or therapeutic agent with at least another therapy or additional therapeutic agent.

[0100] In some aspects, a healthcare benefits provider can authorize or deny, for example, collection of a sample, processing of a sample, submission of a sample, receipt of a sample, transfer of a sample, analysis or measurement a sample, quantification a sample, provision of results obtained after analyzing/measuring/quantifying a sample, transfer of results obtained after analyzing/measuring/quantifying a sample, comparison/scoring of results obtained after analyzing/measuring/quantifying one or more samples, transfer of the comparison/score from one or more samples, administration of a therapy or therapeutic agent, commencement of the administration of a therapy or therapeutic agent, cessation of the administration of a therapy or therapeutic agent, continuation of the administration of a therapy or therapeutic agent, temporary interruption of the administration of a therapy or therapeutic agent, increase of the amount of administered therapeutic agent, decrease of the amount of administered therapeutic agent, continuation of the administration of an amount of a therapeutic agent, increase in the frequency of administration of a therapeutic agent, decrease in the frequency of administration of a therapeutic agent, maintain the same dosing frequency on a therapeutic agent, replace a therapy or therapeutic agent by at least another therapy or therapeutic agent, or combine a therapy or therapeutic agent with at least another therapy or additional therapeutic agent.

[0101] In addition a healthcare benefits providers can, e.g., authorize or deny the prescription of a therapy, authorize or deny coverage for therapy, authorize or deny reimbursement for the cost of therapy, determine or deny eligibility for therapy, etc.

[0102] In some aspects, a clinical laboratory can, for example, collect or obtain a sample, process a sample, submit a sample, receive a sample, transfer a sample, analyze or measure a sample, quantify a sample, provide the results obtained after analyzing/measuring/quantifying a sample, receive the results obtained after analyzing/measuring/quantifying a sample, compare/score the results obtained after analyzing/measuring/quantifying one or more samples, provide the comparison/score from one or more samples, obtain the comparison/score from one or more samples,

[0103] The above enumerated actions can be performed by a healthcare provider, healthcare benefits provider, or patient automatically using a computer-implemented method (e.g., via a web service or stand-alone computer system).

II. Methods and Compositions for Coagulation Activity Testing

[0104] The standard methodology for determining coagulation factor levels in use today is the one stage coagulation factor clotting assay (FIG. 2). A major drawback of this assay is that one cannot use whole blood samples. A typical one stage coagulation factor clotting assay requires, for example (i) venous blood drawn into sodium citrate anticoagulant, (ii) centrifugation to obtain a plasma sample, (iii) laboratory bench top coagulation analyzers and specifically trained laboratory personnel, (iv) liquid reagent preparation and standard curve construction, (v) multiple step assay procedures, (vi) dilution of patient plasma, (vii) mix with factor deficient plasma to mask inter-individual phenotypic variation, (viii) pre-incubation with non-physiological contact phase activators to generate an activated factor, e.g., Factor XIa, (ix) addition of Ca^{+2} to initiate clotting, (x) optical (most common) or mechanical clot detection, (xi) derivation of factor level from Log-Linear (most common) plot of coagulation factor concentration versus clot time (reliable range for standard instrument systems using log-linear fits is ~3% - 120% of normal; high end instruments have incorporated sophisticated software packages that can return accurate values below 1%).

[0105] To address the drawbacks of conventional one stage coagulation factor clotting assays, the present disclosure provides a modified coagulation assay which, in contrast with a standard coagulation assay, can operate using a whole blood sample, for example, fingerstick blood. Instead of pre-incubating the sample with a non-physiological contact phase activators, e.g., kaolin, typically used in laboratory-based assays, the assays disclosed herein use an activation mixture comprising an activated coagulation factor-phospholipid complex. This activation mixture is dried onto a solid substrate, e.g., a test strip.

[0106] Accordingly, the disclosed assays can be performed in point of care analyzers that do not require specially trained laboratory personnel. This general assay format, in which a patient sample (plasma or whole blood) can be applied directly to the solid substrate containing dried assay chemistry, is referred to as the Standard Factor Monitoring System ("Standard FMS") assay throughout the present disclosure.

[0107] In specific aspects of the present disclosure, the Standard FMS assays can be applied to determining coagulation activity of Factor VIII, *e.g.*, measured as clotting time. For the Standard FMS Factor VIII assay, the activated coagulation factor-phospholipid complex can comprise, for example, a mixture of purified activated Factor IX (Factor IXa; abbreviated as FIXa) and phospholipid vesicles, wherein the activation mixture is dried onto a solid substrate. In other specific aspects of the present disclosure, the Standard FMS assay can be applied to determining coagulation activity of Factor IX, *e.g.*, measured as clotting time. For the Standard FMS Factor IX assay, the activated coagulation factor-phospholipid complex can comprise, for example, a mixture of purified activated Factor XI (Factor XIa; abbreviated as FXIa) and phospholipid vesicles, wherein the activation mixture is dried onto a solid substrate. In some aspects, the assays disclosed herein require no preincubation of the samples with the activators mixture.

[0108] In order to address the observed phenotypic variability between samples from the same donor or between donors, the Standard FMS assay can be modified. In some aspects of the present disclosure, less sensitive phospholipid blends in the activator mixture can be used to reduce phenotypic variability. In other aspects, adding a variety of purified coagulation factors to the sample, *e.g.*, Factor II, Factor VII, Factor VIII, Factor IX, Factor X, Factor XI, Factor XII, Factor XIII, fibrinogen, vWF, or Tissue Factor can also reduce phenotypic variability. In other aspects, adding inhibitors to the sample, *e.g.*, C1I, aprotinin, ϵ -aminocaproic acid (EACA), D-Phenylalanyl-L-prolyl-L-arginine chloromethyl ketone-Factor VIIa (FPRCK-FVIIa), or anti-FVIII monoclonal antibodies can also reduce phenotypic variability. Accordingly, the present disclosure provides also a variant of the Standard FMS assay, referred to as the "Alternate FMS" assay throughout the instant disclosure. This Alternate FMS assay is essentially a hybrid between the Standard FMS assay and a one stage factor assay (*e.g.*, an aPTT assay) which is less susceptible to phenotypic variability. The Alternate FMS assay also utilizes an activation mixture comprising a coagulation factor (*e.g.*, FIXa or FXIa) and a phospholipid vesicle preparation dried on the solid substrate (*e.g.*, a disposable test strip). In the plasma based Alternate FMS assay, one part of sample (*e.g.*, hemophilia plasma or fingerstick whole blood) can be mixed with a volume of a corresponding sample that has been depleted of the assay target factor (referred to as "substrate sample" throughout the instant disclosure). In this manner, the variability of non-target sample components can be normalized by addition of the substrate sample. This combination of sample (*e.g.*, hemophilia plasma or fingerstick whole blood) and

substrate sample can be done in an all-liquid system, resulting in a dilution of the sample, thus increasing the lower level of detection of the assay. In some aspects, the sample is diluted with substrate sample at about a 1:2 ratio, at about 1:3 ratio, at about a 1:4 ratio, or at about a 1:5 ratio. Dilution ratios can be adjusted above or below the disclosed ratios using routine experimentation.

[0109] As disclosed above, both the Standard FMS assay and the Alternate FMS assays use an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the composition is dried onto a solid substrate. The activation mixture can contain all the substances necessary for the determination of coagulation factor activity, *e.g.*, via measurement of clotting time. These necessary substances are usually an activated coagulation factor functioning as coagulation activator component, phospholipids, and optionally divalent cations.

[0110] The activation mixtures disclosed herein generally do not contain stabilizers, however, in some aspects of the present disclosure, the activation mixture can contain one or more stabilizers known in the art, such as amino acids (*e.g.*, D-alanine, L-alanine, beta-alanine, etc.). Suitable concentrations of stabilizers are known in the art or can be routinely determined. In some specific aspects, the activation mixture disclosed herein consists of or substantially consists of an activated coagulation factor and a phospholipid mixture, *i.e.*, the activation mixture it does not contain, *e.g.*, divalent cations, stabilizers such as albumin or amino acids, or additional coagulation factor activators or inhibitors.

[0111] In some aspects, the solid substrate can be, *e.g.*, paper, plastic, glass, ceramic material, metal, and combinations thereof. The solid substrate can be, for example, the surface on a test strip, test stick, reaction chamber, cartridge, chip, well plate, or array used in an apparatus to measure coagulation factor activity or coagulation time. In some aspects, the solid substrate can be a membrane, which can be single layered or multilayered. In some aspects, the solid substrate is the surface of a disposable test strip. In other aspects, the solid substrate is the wall in a well in a plastic cartridge. In other aspects, the solid substrate is the wall of a well in a multiwell plate (*e.g.*, a 96-well plate). In some aspects, the solid substrate is the wall of a capillary. In other aspects, the solid substrate is the wall of a vial. In other aspects, the solid substrate is a surface in a mechanical mixing component of a measurement apparatus.

[0112] The solid substrate can be made of any suitable material which preferably has good thermal conductivity, clarity for optical transmission, mechanical properties for easy construction, surface properties that allow for uniform drying and stability of the activation mixture, and neutrality to the liquid medium in the sample to prevent interference with the

coagulation assay. For this purpose, plastic are especially well suited. Suitable plastics include, for example, those with high free surface energies and low water sorption, including PETG, polyester (MYLAR[®]), polycarbonate (LEXAN[®]), polyvinyl chloride, polystyrene, SAN, acrylonitrile-butadiene-styrene (ABS) (e.g., CYCOLAC[®]), etc. In some aspects, plastics and other materials used as solid substrates can be hydrophobic, which would make it difficult to uniformly coat the surface with the activation mixtures disclosed here. Therefore, in some aspects, the substrate can be coated with another reagent (e.g., chemicals such as poly(3-hydroxybutyrate-co-3-hydroxy-hexanoate) (PHBHHx), poly(3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV), or polylactic acid (PLA); or proteins such as collagen or fibronectin) that would render the surface of the substrate hydrophilic and permit attachment of the activation mixture to the surface. In other aspects, the substrate can be physically modified by plasma etching or corona treating to render its surface hydrophilic.

[0113] The activation mixture can be provided, for example, (i) already dried onto a solid substrate, (ii) in a liquid to be dried *in situ*, or (iii) in a dry form (e.g., lyophilized form) to be reconstituted and dried onto the solid substrate. Dry components can be provided separately or in a premixed form. The activation mixture can be dried onto the solid substrate by using methods known in the art. For example, the drying of the activation mixture can be accomplished by air drying (e.g., at room temperature), drying under an inert gas stream (e.g., nitrogen or argon), vacuum drying, lyophilizing, desiccant drying, convective drying, etc. The term drying "onto" a solid substrate also encompasses drying the activation mixture "into" a porous substrate. In this respect, the dry activation mixture can be, for example, located into porous matrices such as sponges, porous paper filters, fleece or felt material, or can be microencapsulated.

[0114] The activation mixture can be applied to the substrate using methods known in the art, e.g., spray painting or lyophilization. In some aspects, the activation mixture can be chemically conjugated to the substrate. Chemical conjugation methods to covalently attach lipids, e.g., phospholipids and/or proteins, e.g., coagulation factors, are known in the art.

[0115] In some aspects, the activation mixture disclosed herein can be used to measure clotting time in samples containing or suspected to contain a coagulation factor, for example, Factor VIII or Factor IX. In some aspects, the coagulation factor is a Factor VIII protein or a fragment, variant, or derivative thereof as disclosed below. In other aspects, the coagulation factor is a Factor IX protein or a fragment, variant, or derivative thereof. In some specific

aspects, the Factor VIII or Factor IX proteins are chimeric proteins (*e.g.*, rFVIII_{IFc} or rFIX_{IFc}) or hybrid proteins.

[0116] In some aspects, the Factor VIII chimeric protein is a single chain (SC) rFVIII_{IFc}. SC rFVIII_{IFc} are disclosed, for example, in U.S. Provisional Application No. 61/668,889, and U.S. Patent No. 7,041,635, both of which are herein incorporated by reference in their entireties.

[0117] The activation mixture disclosed herein can contain an activated coagulation factor, or alternatively a hematologically equivalent, such, as a fragment, variant, or derivative thereof.

[0118] In some aspects, for example to apply the methods disclosed herein to measure the coagulation activity of a Factor VIII protein (or a fragment, variant, derivative, chimeric protein or hybrid protein thereof), the activated coagulation factor is a Factor IXa protein or a fragment, variant, or derivative thereof. In some specific aspects, a Factor IXa protein (or a fragment, variant, derivative, chimeric protein or hybrid protein thereof) is present in the activation mixture composition prior to drying within a range of about 0.01 U/mL to about 0.05 U/mL. In some aspects, the concentration of Factor IXa protein or a fragment, variant, or derivative thereof is about 0.01 U/mL, about 0.02 U/mL, about 0.03 U/mL, about 0.04 U/mL, about 0.05 U/mL, about 0.06 U/mL, about 0.07 U/mL, about 0.08 U/mL, about 0.09 U/mL, or about 0.1 U/mL. In some aspects, the concentration of Factor IXa protein or a fragment, variant, or derivative thereof is at least about 0.1 U/mL.

[0119] In other aspects, for example to apply the methods disclosed herein to measure the coagulation activity of a Factor IX protein or a fragment, variant, or derivative thereof, the activated coagulation factor is a Factor XIa protein or a fragment, variant, or derivative thereof. In some specific aspects, the Factor XIa protein or a fragment, variant, or derivative thereof is present in the activation mixture composition prior to drying within a range of about 0.01 U/mL to about 0.05 U/mL. In some aspects, the concentration of Factor XIa protein or a fragment, variant, or derivative thereof is about 0.01 U/mL, about 0.02 U/mL, about 0.03 U/mL, about 0.04 U/mL, about 0.05 U/mL, about 0.06 U/mL, about 0.07 U/mL, about 0.08 U/mL, about 0.09 U/mL, or about 0.1 U/mL. In some aspects, the concentration of Factor XIa protein or a fragment, variant, or derivative thereof is at least 0.1 U/mL. In some aspects, the concentration of Factor XIa protein or a fragment, variant, or derivative thereof is about 0.01 mg/mL, about 0.02 mg/mL, about 0.03 mg/mL, about 0.04 mg/mL, about 0.05 mg/mL, about 0.06 mg/mL, about 0.07 mg/mL, about 0.08 mg/mL, about 0.09 mg/mL, or about 0.1 mg/mL. In some aspects, the

concentration of Factor XIa protein or a fragment, variant, or derivative thereof is about 0.1 mg/mL. In some aspects, the concentration of Factor XIa protein or a fragment, variant, or derivative thereof is about 0.10 mg/mL, about 0.15 mg/mL, about 0.20 mg/mL, about 0.25 mg/mL, about 0.30 mg/mL, about 0.35 mg/mL, about 0.40 mg/mL, about 0.45 mg/mL, or about 0.50 mg/mL.

[0120] One skilled in the art would understand that other activated coagulation factors and cofactors can be used instead of Factor IXa and FXIa depending on the coagulation factor tested in the coagulation assay.

[0121] The activation mixture contains a phospholipid mixture comprising at least one phospholipid. In some aspects, the phospholipid mixture comprises 2 phospholipids. In other aspects, the phospholipid mixture comprises 3 phospholipids. In other aspects, the phospholipid mixture comprises more than three phospholipids. In other aspects, the phospholipid mixture comprises at least one phospholipid in combination with at least another lipid, e.g., a fatty acid or cholesterol.

[0122] In some specific aspects, the composition of the phospholipid mixture is defined, i.e., phospholipid(s) and other lipid components (if present) are combined according to predetermined ratios. In other aspects, the composition of phospholipid mixture is not defined, e.g., the phospholipid mixture is obtained from an animal and/or vegetal tissue extract (e.g., egg, soy, etc). Chloroform extracts from rabbit brain are an example of suitable phospholipid mixture obtained from a tissue extract known in the art. In some aspects, the phospholipids can be natural. In other aspects, the phospholipids can be synthetic. In some aspects, the phospholipids are a mixture of natural and synthetic phospholipids. The phospholipids in the phospholipid mixture can be, for example, phosphatidylcholine, phosphatidylserine, phosphatidylglycerol, phosphatidic acid, phosphatidylethanolamine, and any combinations thereof.

[0123] Synthetic phospholipics that can be present in the phospholipid mixture include, for example, synthetic phosphatidic acid (e.g., DMPA, DPPA, DSPA), synthetic phosphatidylcholine (e.g., DDPC, DLPC, DMPC, DPPC, DSPC, DOPC, POPC, DEPC), synthetic phosphatidylglycerol (e.g., DMPG, DPPG, DSPG, POPG), synthetic phosphatidylethanoamine (e.g., DMPE, DPPE, DSPE, DOPE), synthetic phosphatidylserine (e.g., DOPS), and combinations thereof.

[0124] In some specific examples, the phospholipid mixture comprises 70 mole-% of phosphatidylcholine and 30 mole-% of phosphatidylserine. In other specific examples, the

phospholipid mixture comprises 80 mole-% of phosphatidylcholine, 10 mole-% of phosphatidylserine, and 10 mole-% of phosphatidylglycerol. In yet other specific examples, the phospholipid mixture comprises 75 mole-% of phosphatidylcholine, 20 mole-% of phosphatidylserine, and 5 mole-% of phosphatidylglycerol.

[0125] In some specific examples, the phospholipid mixture consists or consists essentially of 70 mole-% of phosphatidylcholine and 30 mole-% of phosphatidylserine. In other specific examples, the phospholipid mixture consists or consists essentially of 80 mole-% of phosphatidylcholine, 10 mole-% of phosphatidylserine, and 10 mole-% of phosphatidylglycerol. In yet other specific examples, the phospholipid mixture consists or consists essentially of 75 mole-% of phosphatidylcholine, 20 mole-% of phosphatidylserine, and 5 mole-% of phosphatidylglycerol.

[0126] In some aspects, the phospholipid mixture comprises at least about 5 mole-%, at least about 10 mole-%, at least about 15 mole-%, at least about 20 mole-%, at least about 25 mole-%, at least about 30 mole-%, at least about 35 mole-%, at least about 40 mole-%, at least about 45 mole-%, at least about 50 mole-%, at least about 55 mole-%, at least about 60 mole-%, at least about 65 mole-%, at least about 70 mole-%, at least about 75 mole-%, at least about 80 mole-%, at least about 85 mole-%, at least about 90 mole-%, or at least about 95 mole-% of phosphatidylcholine.

[0127] In some aspects, the phospholipid mixture comprises at least about 5 mole-%, at least about 10 mole-%, at least about 15 mole-%, at least about 20 mole-%, at least about 25 mole-%, at least about 30 mole-%, at least about 35 mole-%, at least about 40 mole-%, at least about 45 mole-%, at least about 50 mole-%, at least about 55 mole-%, at least about 60 mole-%, at least about 65 mole-%, at least about 70 mole-%, at least about 75 mole-%, at least about 80 mole-%, at least about 85 mole-%, at least about 90 mole-%, or at least about 95 mole-% of phosphatidylserine.

[0128] In some aspects, the phospholipid mixture comprises at least about 5 mole-%, at least about 10 mole-%, at least about 15 mole-%, at least about 20 mole-%, at least about 25 mole-%, at least about 30 mole-%, at least about 35 mole-%, at least about 40 mole-%, at least about 45 mole-%, at least about 50 mole-%, at least about 55 mole-%, at least about 60 mole-%, at least about 65 mole-%, at least about 70 mole-%, at least about 75 mole-%, at least about 80 mole-%, at least about 85 mole-%, at least about 90 mole-%, or at least about 95 mole-% of phosphatidylglycerol.

[0129] In some aspects, the phospholipid mixture further comprises cholesterol. In some aspects, the phospholipid mixture comprises at least about 1 mole-%, at least about 2 mole-%, at least about 3 mole-%, at least about 4 mole-%, at least about 5 mole-%, at least about 6 mole-%, at least about 7 mole-%, at least about 8 mole-%, at least about 9 mole-%, at least about 10 mole-%, at least about 11 mole-%, at least about 12 mole-%, at least about 13 mole-%, at least about 14 mole-%, at least about 15 mole-%, at least about 16 mole-%, at least about 17 mole-%, at least about 18 mole-%, at least about 19 mole-%, or at least about 20 mole-% of cholesterol.

[0130] In some aspects, the phospholipid mixture is combined with the activated coagulation factor prior to drying onto a solid substrate. In some aspects, the phospholipid mixture is in vesicle form (*e.g.*, a liposome or other artificial lipid vesicle). In some aspects, the vesicles are unilamellar vesicles, *e.g.*, small unilamellar vesicles. Unilamellar vesicles can be produced using methods known in the arts, *e.g.*, extrusion or sonication. Typically, small unilamellar vesicles are formed by sonication (*e.g.*, tip or bath sonication) from large multilamellar vesicles. Large unilamellar vesicles can be formed, for example, by extrusion or by allowing small unilamellar vesicles to coalesce.

[0131] Divalent cations are optionally present in the activation mixture. In some aspects, divalent cations are present in the sample (*e.g.*, a recalcified sample) and in the activation mixture. In other aspects, divalent cations can be added after the sample has contacted the activation mixture.

[0132] In some aspects, the divalent cations are calcium ions. Any chemical source of calcium cations can be used, *e.g.*, CaCl_2 , $\text{Ca}(\text{NO}_2)_2$, CaSO_4 , or other inorganic or organic calcium cation-containing compounds.

[0133] The methods disclosed herein can be applied to any sample containing a coagulation factor or suspected of containing a coagulation factor. In some aspects, the sample can be whole blood, citrated or equivalently stabilized blood, plasma, or other fluid sample containing or suspected of containing a coagulation factor. In some aspects, the sample is decalcified, *e.g.*, decalcified plasma. Plasma can be decalcified, for example, by adding chelators such as EDTA. In other aspects, the sample is recalcified, *e.g.*, recalcified plasma. Methods to decalcify blood samples, *e.g.*, plasma, and specific conditions and calcium concentrations for recalcification are well known in the art.

[0134] Measurements of coagulation, *e.g.*, clotting time (Ct) measurements, using the activation mixtures disclosed herein, wherein the activation mixture is dried onto a solid

substrate, can be carried out manually by visual observation of clot formation. However, measurement of coagulation, *e.g.*, clotting time (Ct) measurement, can also be performed using optical or mechanical measurement instruments such as those marketed, *e.g.*, by the Amelung, Baxter, Labor, Medtronic, CoaguSense, Roche Diagnostics (*e.g.*, CoaguChek[®] I, II, XS; Coumatrak[®]), CardioVascular Diagnostics (*e.g.*, TAS[®]), Organon Teknica (Coag-A-Mate[®]), Haemoscope (TEG), Pentapharm (ROTEM), Medirox, Siemens, Hemotek, Helena Laboratories, and Behring companies. Measurements can also be performed using point-of-care devices discussed *infra*.

[0135] The activation mixtures disclosed herein, wherein the activation mixture is dried onto a solid substrate, can be applied to a variety of methods for measuring coagulation, and/or the concentration of coagulation factors in biological samples, *e.g.*, blood or plasma, and/or to determine the effect or concentration of direct or indirect inhibitors of coagulation. Such methods include both chromogenic assays and so-called "clotting methods" such as the aPTT assay. In general, these "clotting methods" are characterized by the fact that coagulation is activated and the time from coagulation activation until detection of clotting in the sample is measured, and in turn clotting time can be converted into direct concentration units by establishing a calibration curve with appropriate calibration reagents.

[0136] In specific aspects of the present disclosure, the activation mixture can be used as a reagent for the measurement of the Factor VIII activity of a Factor VIII protein (or a fragment, variant, derivative, chimeric protein, or hybrid protein thereof) in a sample. In one specific aspect, such activation mixture comprises 80% of 0.1 mg/mL Factor IXa and 20% of a phospholipid mixture comprising 75 mole-% of phosphatidylcholine, 20 mole-% of phosphatidylserine, and 5 mole-% of phosphatidylglycerol, wherein said activation mixture is dried onto a solid substrate. In another specific aspect, such activation mixture consists or substantially consists of 80% of 0.1 mg/mL Factor IXa and 20% of a phospholipid mixture comprising 75 mole-% of phosphatidylcholine, 20 mole-% of phosphatidylserine, and 5 mole-% of phosphatidylglycerol, wherein said activation mixture is dried onto a solid substrate.

[0137] In specific aspects of the present disclosure, the activation mixture can be used as a reagent for the measurement of the Factor IX activity of a Factor IX protein (or a fragment, variant, derivative, chimeric protein, or hybrid protein thereof) in a sample. In one specific aspect, such activation mixture comprises 80% of Factor Xla suspension and 20% of a phospholipid mixture comprising 75 mole-% of phosphatidylcholine, 20 mole-% of

phosphatidylserine, and 5 mole-% of phosphatidylglycerol, wherein said activation mixture is dried onto a solid substrate. In another specific aspect, such activation mixture consists or substantially consists of 80% of Factor XIa suspension and 20% of a phospholipid mixture comprising 75 mole-% of phosphatidylcholine, 20 mole-% of phosphatidylserine, and 5 mole-% of phosphatidylglycerol, wherein said activation mixture is dried onto a solid substrate. The exact amount of FXIa suspension needed varies depending on the specific activity of this reagent and is titrated for optimal amount and may include approximately 0.1 mg/mL to approximately 0.5 mg/mL.

[0138] Also provided in the present disclosure is a kit for performing a measurement of coagulation factor activity or coagulation time in a sample, wherein said kit comprises the components to prepare any of the activation mixtures disclosed herein in one or more vials, as well as instructions to dry the components to prepare any of the activation mixtures disclosed herein onto a solid substrate. Such kit can comprise, for example, (i) a solution comprising both an activated coagulation factor and phospholipid vesicles in a single vial, or (ii) separate vials, one of them containing a solution of activated coagulation factor and a second vial containing a solution of phospholipid vesicles, or (iii) a vial containing a solution of activated coagulation factor and a second vial containing a dried phospholipid mixture to be reconstituted to produce phospholipid vesicles, etc. Thus, in some aspects, the kit comprises one or more components in a dry form or non-dry form in one or more vials, instructions for reconstituting or mixing the components in the kit, and instruction for drying the activation mixture onto a solid substrate.

[0139] Also provided in the present disclosure is a sample holder for performing a blood coagulation assay, comprising a surface coated with any one of the activation mixtures disclosed herein, wherein the activation mixture is dried onto a solid substrate. For example, the sample holder can be a test strip, a test stick, a reaction chamber, a cup, a cuvette, a cartridge, a chip, a well plate, an array, a membrane, a capillary, etc. A particular advantage of using a dried activation mixture coating a surface (as opposed to using a fluid reagent) in a sample holder is that it extends the shelf life of the sample holder. A second advantage is that using a dried activation mixture applied to coat the inner walls of a sample holder (e.g., a cartridge, a well or a cuvette) is that the operator does not need to mix, pour, or otherwise deal with liquid reactants.

[0140] In performing the assays disclosed herein (e.g., the Standard FMS assay or the Alternate FMS assay), a great variation in protein concentrations, incubation times, reagent concentrations, and temperatures can be employed. The selection of particular assay parameters

will depend on the coagulation factor to be assayed as well as the source, type and size of the sample to be assayed, the anticipated levels of coagulation factor contained therein, and the threshold of sensitivity desired. Taking these circumstances into consideration, selection of assay parameters will be apparent to those skilled in the art.

[0141] The assays disclosed herein (*e.g.*, the Standard FMS assay or the Alternate FMS assay) can be used in methods for determining clotting time in a patient having a bleeding disorder. Accordingly, the present disclosure provides a method for determining clotting time in a patient having bleeding disorder comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; and, (b) measuring the time between the contacting of the activation mixture with the blood sample and the onset of clotting, thereby calculating the clotting time (Ct).

[0142] The present disclosure also provides a method of treating a patient having a bleeding disorder comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct), wherein Ct indicates whether the patient will benefit from administration of a treatment; and, (c) administering the treatment to the patient if Ct indicates that the patient will benefit from administration of the treatment. Also provided is a method of treating a patient having a bleeding disorder comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct), wherein Ct indicates whether the patient will benefit from administration of a treatment; and, (c) instructing a healthcare provider to administer the treatment to the patient if Ct indicates that the patient will benefit from administration of the treatment.

[0143] The disclosure also provides a method of optimizing a bleeding disorder treatment in a patient comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the

clotting time (Ct), wherein Ct correlates with a therapeutically efficacious treatment; and, (c) administering an optimized treatment to the patient, wherein the treatment is maintained or adjusted. Also provided is a method of optimizing a bleeding disorder treatment in a patient comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct), wherein Ct correlates with a therapeutically efficacious treatment; and, (c) instructing a healthcare provider to optimize the treatment administered, wherein the treatment is maintained or adjusted.

[0144] The instant disclosure also provides a method of diagnosing whether a patient is in need of treatment for a bleeding disorder comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct), wherein Ct indicates whether the patient has a bleeding disorder; and, (c) providing a treatment for the bleeding disorder if the patient is in need thereof. Also provided is a method of diagnosing whether a patient is in need of treatment for a bleeding disorder comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct), wherein Ct indicates whether the patient has a bleeding disorder; and, (c) instructing a healthcare provider to provide treatment for the bleeding disorder if the patient is in need thereof.

[0145] Also provided in the present disclosure is a method of monitoring the efficacy of a bleeding disorder treatment administered to a patient comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); and, (c) comparing the measured Ct with the Ct obtained from a corresponding standard, wherein the standard is representative of a

therapeutically efficacious treatment, and wherein a similarity between the patient's results and the standard is indicative of efficacy of the patient's current treatment; and, (d) maintaining or adjusting the patient's treatment based on the relative difference between the patient's results and the corresponding standard. Also provided is a method of monitoring the efficacy of a bleeding disorder treatment administered to a patient comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); and, (c) comparing the measured Ct with the Ct obtained from a corresponding standard, wherein the standard is representative of a therapeutically efficacious treatment, and wherein a similarity between the patient's results and the standard is indicative of efficacy of the patient's current treatment; and, (d) instructing a healthcare provider to maintain or adjusting the patient's treatment based on the relative difference between the patient's results and the corresponding standard.

[0146] The present disclosure also provides a method for determining a coagulation factor level in a bleeding disorder patient, comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); and, (c) correlating the Ct value with the level of coagulation factor in the sample. The correlation between Ct and coagulation factor level (%Factor) can be calculated, for example, according to the formula:

$$Ct = A \times \ln(\%Factor) + B$$

wherein, for each coagulation factor, A is a constant value corresponding to the slope of a Ct versus coagulation factor concentration dose-response, and B is patient-specific off-set value.

[0147] For a given coagulation factor, the A values for dose response curves plotting concentration of coagulation factor (%Factor) versus Ct are similar for all patients, whereas the B off-set values are different due to patient-specific global coagulation differences. The variability in B values can be addressed, for example, by optimizing the chemistry of the activation mixture so that there is no difference in B values among patients. The resulting correlation between

concentration of factor and Ct can be used in a "Ready to Use Factor Monitoring Device" that does not require patient-specific calibration. Such device can be, for example, a point-of-care device.

[0148] Alternatively, the variability in B values can be addressed by customizing the device for each patient. For example, Ct can be measured during an initial (training) visit using the Standard FMS assay or Alternate FMS assay disclosed herein, and venous sample for standard laboratory analysis can be obtained at the same time. The B value, offset between Ct value from FMS assay(s) and the laboratory assays, could be provided to the patient (e.g., as an ID value). The ID value could be used to program the device, thus providing a "Customized Factor Monitoring Device" specifically customized for a single patient. Multiple patient IDs would be possible per device. Such device can be, for example, a point-of-care device.

[0149] The instant disclosure also provides a method for determining a pharmacokinetic (PK) parameter in a bleeding disorder patient, comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); and, (c) correlating a PK with the calculated Ct value, thereby determining the value of the PK parameter.

[0150] Also provided in the present disclosure is a method of treating a patient having a bleeding disorder comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); (c) determining a PK parameter based on Ct, wherein the PK parameter indicates that the patient will benefit from administration of the treatment; and, (d) administering the treatment to the patient if the PK parameter indicates that the patient will benefit from administration of the treatment. Also provided in the present disclosure is a method of treating a patient having a bleeding disorder comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); (c) determining a PK parameter based on Ct, wherein

the PK parameter indicates that the patient will benefit from administration of the treatment; and, (d) instructing a healthcare provider to administer the treatment to the patient if the PK parameter indicates that the patient will benefit from administration of the treatment.

[0151] The present disclosure also provides is a method of optimizing a bleeding disorder treatment in a patient comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); (c) determining a PK parameter based on Ct, wherein the PK parameter correlates with a therapeutically efficacious treatment; and, (d) administering an optimized treatment to the patient, wherein the treatment is maintained or adjusted. The present disclosure also provides a method of optimizing a bleeding disorder treatment in a patient comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); (c) determining a PK parameter based on Ct, wherein the PK parameter correlates with a therapeutically efficacious treatment; and, (d) instructing a healthcare provider to administer an optimized treatment to the patient, wherein the therapy is maintained or adjusted.

[0152] The instant disclosure also provides a method of diagnosing whether a patient is in need of treatment for a bleeding disorder comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); (c) determining a PK parameter based on Ct, wherein the PK parameter indicates whether the patient has a bleeding disorder; and, (d) providing treatment for the bleeding disorder if the patient is in need thereof.

[0153] Also provided in the instant disclosure is a method of diagnosing whether a patient is in need of treatment for a bleeding disorder comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the

onset of clotting, thereby calculating the clotting time (Ct); and, (c) determining a PK parameter based on Ct, wherein the PK parameter indicates whether the patient has a bleeding disorder; and, (d) instructing a healthcare provider to provide therapy to treat the bleeding disorder if the patient is in need thereof.

[0154] The present disclosure also provides a method of monitoring the efficacy of a bleeding disorder treatment administered to a patient comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); and, (c) determining a PK parameter based on Ct; (d) comparing the PK parameter with the PK obtained from a corresponding standard, wherein the standard is representative of a therapeutically efficacious treatment, and wherein a similarity between the patient's results and the standard is indicative of efficacy of the patient's current treatment; and, (e) maintaining or adjusting the patient's treatment based on the relative difference between the patient's results and the corresponding standard. Also provided is a method of monitoring the efficacy of a bleeding disorder treatment administered to a patient comprising (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); (c) determining a PK parameter based on Ct; (d) comparing the PK parameter with the PK obtained from a corresponding standard, wherein the standard is representative of a therapeutically efficacious treatment, and wherein a similarity between the patient's results and the standard is indicative of efficacy of the patient's current treatment; and, (e) instructing a healthcare provider to maintain or adjust the patient's treatment based on the relative difference between the patient's results and the corresponding standard.

[0155] In some aspects, the PK is terminal half-life ("HL"). In other aspects, the PK is time to through ("T"). The PK parameters disclosed herein as well as other PK parameters known in the art can be calculated from Ct and additional parameters that can be determined experimentally and/or from pharmacodynamic simulation and/or pharmacokinetic simulations. For example, pharmacokinetic and pharmacodynamics parameters can be calculated for a certain coagulation factor, for a certain population, or for a certain administration route, dosage, or other

condition based on simulations conducted on data obtained from a single patient or from multiple patients (e.g., patients in a clinical trial).

[0156] In some aspects, HL can be calculated according to the formula:

$$HL = -0.693 \times (T_2 - T_1) \times A / (C_{t_1} - C_{t_2})$$

[0157] wherein, for each coagulation factor, A is a constant value corresponding to the slope of a Ct versus coagulation factor concentration dose-response, T₁ and T₂ are times at which Ct is measured, and C_{t1} and C_{t2} are Ct values measured at T₁ and T₂, respectively. In this calculation, the offset value B becomes irrelevant, i.e., interpatient differences in global coagulation do not affect terminal half-life. The possibility of repeating Ct measures on a point-of-care device on multiple days applying the method and compositions disclosed herein (for example, one measurement per day for 5 to 8 days) means that the likely result would be far more accurate than terminal half-life values obtained using one or two traditional laboratory-based measurements.

[0158] In some aspects, the patient-specific terminal half-life calculated according to the method disclosed above can be combined with pharmacokinetic and/or pharmacodynamics data. For example, product-specific *in vivo* recovery and distribution phase (α -phase) half-life data can be obtained via population modeling using data obtained from clinical trials. "*In vivo* recovery" ("IVR") is generally represented by the incremental recovery (K-value), which is the observed peak activity minus predose level and then divided by the dose. IVR can also be calculated on a percentage basis. The mean IVR can be determined in a patient population, or the individual IVR can be determined in a single subject. Product-specific *in vivo* recovery and distribution phase (α -phase) half-life data can be combined to patient-specific terminal half-life data to calculate time to trough (T) according to the formula:

$$T = -1.44 \times HL / (A \times (C_{t_{\text{measured}}} - C_{t_{\text{trough}}}))$$

wherein for each coagulation factor A is a constant value corresponding to the slope of a Ct versus coagulation factor concentration dose-response, and HL is the terminal half-life, C_{t_{measured}} is Ct measured at certain time point, and C_{t_{trough}} is patient-specific clot time at trough. In some aspects, the patient is administered a new dose of coagulation factor every T interval.

[0159] In some aspects, the sample used in the methods of treating, optimizing a treatment, diagnosing whether a patient needs a treatment, monitoring the efficacy of the treatment, or in the methods for determining clotting times, coagulation factor levels, and pharmacokinetic (PK) parameters disclosed herein, comprises, *e.g.*, whole blood, citrated or equivalently stabilized blood, plasma, or other fluid sample containing or suspected of containing a coagulation factor. In some aspects, the sample is whole blood, for example venous blood obtained via phlebotomy, whereas in other aspects the blood is fingerstick blood. In some specific aspects, a single drop of fingerstick blood is required to practice the disclosed methods.

[0160] In other aspects, the sample is plasma. Samples, *e.g.*, plasma or blood, can be refrigerated or used at room temperature. In some aspects, samples, *e.g.*, plasma or blood, can be frozen and thawed prior to contacting the sample with the activation mixture. In other cases, the sample has not been frozen and thawed prior to contacting the sample with the activation mixture. In some aspects, the sample is decalcified, *e.g.*, by adding a chelator such as EDTA to the sample. In other aspects, the decalcified sample is recalcified prior to contacting the sample with the activation mixture by adding a solution containing divalent ions, *e.g.*, calcium ions. In certain aspects, the decalcified sample is recalcified after contacting the sample with the activation mixture.

[0161] In certain aspects, variability between samples can be reduced by adding, for example, a purified coagulation factor or an inhibitor of coagulation to the sample. Purified coagulation factor that can be added to the sample include, for example, Factors II, Factor VII, Factor VIII, Factor IX, Factor X, Factor XI, Factor XII, Factor XIII, Fibrinogen, vWF, Tissue Factor, and combinations thereof. Coagulation inhibitors that can be added to the sample include, for example, CTI, aprotinin, ϵ -aminocaproic acid (EACA), D-Phenylalanyl-L-prolyl-L-arginine chloromethyl ketone-Factor VIIa (FPRCK-FVIIa), anti-coagulation factor monoclonal antibodies, and combinations thereof. In some aspects, the one purified coagulation factor can be added to the sample. In other cases, more than one purified coagulation factor can be added to the sample. In some cases, one coagulation inhibitor can be added to the sample. In other cases, more than one coagulation inhibitor can be added to the sample. In some cases, a combination comprising at least one purified coagulation factor and at least one coagulation inhibitor can be added to the sample.

[0162] In some cases, the sample can be diluted, for example, with substrate sample (*i.e.*, sample that has been depleted of the assay target factor). This dilution can consist, for example,

of one part of sample diluted with three parts of substrate sample. In some aspects, the sample is diluted with substrate sample at about a 1:2 ratio, at about 1:3 ratio, at about a 1:4 ratio, or at about a 1:5 ratio. Dilution ratios can be adjusted above or below the disclosed ratios using routine experimentation.

[0163] In some aspects, the methods of treating, optimizing a treatment, diagnosing whether a patient needs a treatment, monitoring the efficacy of the treatment, or in the methods for determining clotting times, coagulation factor levels, and pharmacokinetic (PK) parameters disclosed herein, use an activation mixture comprising an activated coagulation factor wherein the factor is a Factor IXa protein or a fragment, variant, or derivative thereof.

[0164] In some aspects, the methods of treating, optimizing a treatment, diagnosing whether a patient needs a treatment, monitoring the efficacy of the treatment, or in the methods for determining clotting times, coagulation factor levels, and pharmacokinetic (PK) parameters disclosed herein, use an activation mixture comprising an activated coagulation factor wherein the factor is a Factor XIa protein or a fragment, variant, or derivative thereof.

[0165] In some aspects, the methods of treating, optimizing a treatment, diagnosing whether a patient needs a treatment, monitoring the efficacy of the treatment, or in the methods for determining clotting times, coagulation factor levels, and pharmacokinetic (PK) parameters disclosed herein, use an activation mixture comprising a phospholipid mixture. This phospholipid mixture can comprise, for example, 1 phospholipid, 2 phospholipids, 3 phospholipids, or more than 3 phospholipids. These phospholipids can be, for example, phosphatidylcholine, phosphatidylserine, or phosphatidylglycerol. The phospholipids in the phospholipid mixture can be, for example, natural phospholipids, synthetic phospholipids, or combinations thereof.

[0166] In some specific aspects, the phospholipid mixture comprises 70 mole-% of phosphatidylcholine and 30 mole-% of phosphatidylserine. In certain specific aspects, the phospholipid mixture consists or essentially consists of 70 mole-% of phosphatidylcholine and 30 mole-% of phosphatidylserine. In other aspects, the phospholipid mixture comprises 80 mole-% of phosphatidylcholine, 10 mole-% of phosphatidylserine, and 10 mole-% of phosphatidylglycerol. In yet other aspects, the phospholipid mixture consists or essentially consists of 80 mole-% of phosphatidylcholine, 10 mole-% of phosphatidylserine, and 10 mole-% of phosphatidylglycerol. In some aspects, the phospholipid mixture comprises 75 mole-% of phosphatidylcholine, 20 mole-% of phosphatidylserine, and 5 mole-% of phosphatidylglycerol. In other aspects, the the phospholipid mixture consists or essentially consists of 75 mole-% of

phosphatidylcholine, 20 mole-% of phosphatidylserine, and 5 mole-% of phosphatidylglycerol. In certain aspects, the phospholipid mixture further comprises cholesterol, for example at a concentration from about 1 to about 20 mole-% of cholesterol.

[0167] In some aspects, the activation mixture used in the methods of treating, optimizing a treatment, diagnosing whether a patient needs a treatment, monitoring the efficacy of the treatment, or in the methods for determining clotting times, coagulation factor levels, and pharmacokinetic (PK) parameters disclosed herein, comprises a phospholipid mixture in lipid vesicle form. In some aspects, the lipid vesicles are small unilamellar vesicles.

[0168] In some aspects, the activation mixture used in the methods of treating, optimizing a treatment, diagnosing whether a patient needs a treatment, monitoring the efficacy of the treatment, or in the methods for determining clotting times, coagulation factor levels, and pharmacokinetic (PK) parameters disclosed herein, further comprises divalent cations, *e.g.*, calcium ions.

[0169] In some aspects, the activation mixture used in the methods of treating, optimizing a treatment, diagnosing whether a patient needs a treatment, monitoring the efficacy of the treatment, or in the methods for determining clotting times, coagulation factor levels, and pharmacokinetic (PK) parameters disclosed herein, can react with a coagulation factor, *e.g.*, Factor VII, Factor VIII, or Factor IX. In some aspects, the Factor VIII coagulation factor is a Factor VIII protein (or a fragment, variant, derivative, chimeric protein, or hybrid protein thereof). In some aspects, the Factor VIII coagulation factor is a chimeric Factor VIII-Fc fusion protein. In some aspects, the Fc portion of the chimeric Factor VIII protein comprises a human Fc domain. In some aspects, the chimeric Factor VIII protein comprises a B-domain deleted Factor VIII. In specific aspects, the chimeric Factor VIII protein comprises SEQ ID NO:6. or SEQ ID NO:2.

[0170] In other aspects, the Factor IX coagulation factor is a Factor IX protein (or a fragment, variant, derivative, chimeric protein, or hybrid protein thereof). In some aspects, the Factor IX coagulation factor is a chimeric Factor IX-Fc fusion protein. In some aspects, the Fc portion of the chimeric Factor IX protein comprises a human Fc domain. In certain specific aspects, the chimeric Factor IX protein comprises SEQ ID NO: 13.

[0171] In some aspects, the activation mixture used in the methods of treating, optimizing a treatment, diagnosing whether a patient needs a treatment, monitoring the efficacy of the treatment, or in the methods for determining clotting times, coagulation factor levels, and

pharmacokinetic (PK) parameters disclosed herein, is dried onto a the solid substrate. This solid substrate can be, for example, paper, plastic, glass, ceramic material, metal, and combinations thereof. In some aspects, the solid substrate is a surface on a test strip, test stick, reaction chamber, cartridge, chip, well plate, or array used in an apparatus to measure coagulation factor activity or coagulation time.

[0172] In some aspects, the patient in the methods of treating, optimizing a treatment, diagnosing whether a patient needs a treatment, monitoring the efficacy of the treatment, or in the methods for determining clotting times, coagulation factor levels, and pharmacokinetic (PK) parameters disclosed herein, has not yet been treated with a coagulation factor. However, in other cases, the patient has received prior coagulation factor treatment, but the treatment has been discontinued for a time period sufficient to deplete the coagulation factor treatment from the patient's blood.

[0173] The methods, compositions, and systems of the present disclosure can be applied to treating a patient or evaluating or determining whether a patient will benefit from administration of a therapeutically effective dose of a therapeutic agent that is capable of treating a bleeding disorder, for example, hemophilia A or hemophilia B. The methods of systems disclosed herein can be used to apply more precise coagulation factor dosing to patients. In a further aspect, the methods and systems disclosed herein can be used to increase the power and effectiveness of clinical trials. Thus, individuals in a study can be monitored and dosages adjusted individually. When the methods of the present disclosure are used for the treatment of bleeding disorders by administration of a coagulation factor, *e.g.*, a Factor VIII or Factor IX protein (or fragment, variants, derivative, chimeric proteins, or hybrid protein thereof), individualized treatment using the methods provided herein can result in fewer disease flare-ups, and thus provide a higher quality of life for the patient. In order to treat a patient, samples from the patient can be obtained before or after the administration of a FV III or FIX polypeptide. In some cases, successive samples can be obtained from the patient after clotting factor treatment has commenced or after treatment has ceased.

[0174] Samples can, *e.g.*, be requested by a healthcare provider (*e.g.*, a doctor) or healthcare benefits provider, obtained and/or processed by the same or a different healthcare provider (*e.g.*, a nurse, a hospital) or a clinical laboratory, and after processing, the results can be forwarded to yet another healthcare provider, healthcare benefits provider or the patient. Similarly, the measuring/determination of clotting times, the comparisons between time points,

and treatment decisions can be performed by one or more healthcare providers, healthcare benefits providers, and/or clinical laboratories. In some cases, the methods, compositions, and systems disclosed herein can be applied in a point-of-care test system.

[0175] The methods described herein can be used for variety of evaluations, including without limitation, analysis of a patient's blood prior to treatment (or after complete washout of prior therapeutic treatment, to evaluate 'baseline' clot formation (which can correlate with severity of the disease) and adding various therapeutic composition(s) such as recombinant FVIII or FIX *ex vivo* to such blood in order to predict the individual's response to therapy. The methods disclosed herein can be applied, for example, to measure clotting time in samples from a patient suffering from a bleeding disorder, samples from a patient suffering from a clotting disorder, or samples from a healthy patient (*e.g.*, prior to surgery). The methods disclosed herein can also be applied, for example, to determine the effect on coagulation of a natural, recombinant, or chimeric clotting factor, a biological (*e.g.*, an antibody or fusion protein), an anticoagulant, or a small molecule drug added to a plasma or blood sample, or present or suspected to be present in a blood or plasma sample from a patient. Thus, the methods disclosed herein are generally applicable to the measurement of coagulation (*e.g.*, by measuring clotting time) in samples from patients suffering or at risk of suffering conditions other bleeding disorders other than hemophilias. For example, in some conditions such as lupus, coagulation can be altered by the presence of lupus anticoagulant, a prothrombotic agent that precipitates the formation of thrombi *in vivo*. Patients with lupus and other conditions causing thrombosis can be treated with anticoagulants. Coagulation can also be altered by substances from animal origin, *e.g.*, hirudin or proteins from snake venoms. Certain drug therapies, for example, warfarin treatment, are known to influence coagulation factor levels. Also patients suffering from consumptive coagulopathies such as thrombosis or disseminated intravascular coagulation (DIC) can present anomalies in coagulation factor levels which require careful clinical management. Successful treatment of these conditions similarly requires accurate determination of serum coagulation factor levels. In managing any of the aforementioned medical conditions, one mode of treatment involves administration of exogenous coagulation factors (*e.g.*, Factor VIII or FIX proteins, fragments, variants or derivatives, for example rFVIII_{Fc} or rFIX_{Fc}). It is essential that the precise concentration of such therapeutic doses be measured, and the quantity of coagulation factor be monitored.

[0176] Accordingly, the methods for diagnosing, treating, optimizing treatment, monitoring treatment, etc. disclosed herein can generally be applied to any diseases, conditions, or any situations in which blood coagulation is compromised or is suspected to be compromised, and also for prophylactic or preventive purposes (for example, to detect the onset of a disease or condition in a patient at risk or with a family history of such disease).

III. Point-of-Care Applications

[0177] In many situations, blood coagulation tests can be performed directly at the point of care without transport of the sample to an separate facility, *e.g.*, a laboratory. The advantages of point-of-care analysis include (i) short turn-around time, as there is no time or only little time needed for transport of the sample, which allows fast monitoring-directed decisions, (ii) transport of the sample to an emergency laboratory can be very expensive, especially at night and when only few samples are to be analyzed, and (iii) self-testing of the patient is possible.

[0178] Available point-of-care methods for analysis of coagulation time have the same limitations as the determination of aPTT in the laboratory, *e.g.*, non-linear dose response, low sensitivity, or high variation between samples and/or patients.

[0179] The methods and compositions of the present disclosure can be used in improved assays for point-of-care analysis of samples, *e.g.*, blood samples such as whole blood samples. Thus, the present disclosure also includes a point-of-care hematological assay wherein the activation mixture disclosed herein is positioned in one or more reaction locations in a test apparatus and a sample of body fluid to be assayed (*e.g.*, whole blood, citrated blood, or plasma) is contacted by the activation mixture.

[0180] As a specific aspect, the present disclosure provides a point-of-care device designed to rapidly test for coagulation levels, *e.g.*, levels of coagulation factor VIII (FVIII) or factor IX (FIX) levels in hemophilia patients, from a finger stick blood sample by using raw clotting times, wherein said point of care device uses a disposable sample holder (*e.g.*, a disposable strip) coated with a activation mixture comprising an activated coagulation factor and a phospholipid mixture, and wherein said activation mixture is dried onto said disposable sample holder.

[0181] The Standard FMS and Alternate FMS assays disclosed herein can be implemented in point-of-care devices and used as a global hemostasis tests by using raw clotting times (Ct) to determine individual pharmacokinetic parameters which in term can be used to

decide treatment. Accordingly, the methods and composition disclosed herein can be applied to measure coagulation activity by implementing them in commercially available point-of-care self-monitoring devices, for example, i-STAT 1 (Abbott Point of Care); INRatio or INRatio2 PT INR Monitors (Alere); RapidPoint (Bayer); Coag-Sense PT/INR Monitoring System (CoaguSense); Actalyke Mini II, Actalyke XL, or Cascade POC (Helena Point of Care); Gem PCL Plus (Instrumentation Laboratory); Hemochrom Response, Hemochron Signature Elite, Hemochron Signature+, or ProTime Microcoagulation System (ITC); ACT Plus, or HMS Plus (Medtronic Cardiac Surgery); CoaguCheck XS Pro PT, CoaguCheck XS PT, CoaguCheck Plus PT (Roche Diagnostics); etc.

IV. Factor VIII and Factor IX Polypeptides

[0182] The methods and compositions provided in the present disclosure can be used in assays to determine the activity of clotting factors, such as Factor VIII and Factor IX polypeptides (including fragments, variants, derivatives, chimeric, and hybrid polypeptides). A detailed description of Factor VIII and Factor IX polypeptides (including fragments, variants, derivatives, chimeric and hybrid polypeptides) whose coagulating activity can be assessed by using the methods and compositions of the present disclosure is provided below.

A. Factor VIII Polypeptides

[0183] "Factor VIII," as used herein, means functional Factor VIII polypeptide in its normal role in coagulation, unless otherwise specified. Thus, the term Factor VIII includes variant polypeptides that are functional. Factor VIII proteins include the human, porcine, canine, and murine Factor VIII proteins. The full length polypeptide and polynucleotide sequences are known, as are many functional fragments, mutants and modified versions. Examples of human Factor VIII sequences are shown as subsequences in SEQ ID NOs: 2, 6, 8, 10, and 12 (Sequence Table 2). Factor VIII polypeptides include, *e.g.*, full-length Factor VIII, full-length Factor VIII minus Met at the N-terminus, mature Factor VIII (minus the signal sequence), mature Factor VIII with an additional Met at the N-terminus, and/or Factor VIII with a full or partial deletion of the B domain. Factor VIII polypeptides include B domain deletions, whether partial or full deletions or single chain FVIII. Factor VIII can be made by recombinant means ("recombinant Factor VIII" or "rFVIII"), *i.e.*, it is not naturally occurring or derived from plasma.

[0184] "B domain" of Factor VIII, as used herein, is the same as the B domain known in the art that is defined by internal amino acid sequence identity and sites of proteolytic cleavage

by thrombin, *e.g.*, residues Ser741-Arg1648 of full length human Factor VIII. The other human Factor VIII domains are defined by the following amino acid residues: A1, residues Ala1-Arg372; A2, residues Ser373-Arg740; A3, residues Ser1690-Ile2032; C1, residues Arg2033-Asn2172; C2, residues Ser2173-Tyr2332. The A3-C1-C2 sequence includes residues Ser1690-Tyr2332. The remaining sequence, residues Glu1649-Arg1689, is usually referred to as the Factor VIII light chain activation peptide. The locations of the boundaries for all of the domains, including the B domains, for porcine, mouse and canine Factor VIII are also known in the art. In certain aspects, the B domain of Factor VIII is deleted ("B domain deleted Factor VIII" or "BDD FVIII"). An example of a BDD FVIII is REFACTO (recombinant BDD FVIII), which has the same sequence as the Factor VIII portion of the sequence in Sequence Table 2A(i) (amino acids - 19 to 1438 or 1 to 1438 of SEQ ID NO:2).

[0185] A "B domain deleted Factor VIII" can have the full or partial deletions disclosed in U.S. Patent Nos. 6,316,226, 6,346,513, 7,041,635, 5,789,203, 6,060,447, 5,595,886, 6,228,620, 5,972,885, 6,048,720, 5,543,502, 5,610,278, 5,171,844, 5,112,950, 4,868,112, and 6,458,563, each of which is incorporated herein by reference in its entirety. In some aspects, a B domain deleted Factor VIII sequence of the present disclosure comprises any one of the deletions disclosed at col. 4, line 4 to col. 5, line 28 and examples 1-5 of U.S. Patent No. 6,316,226 (also in US 6,346,513). In some aspects, a B domain deleted Factor VIII of the present disclosure has a deletion disclosed at col. 2, lines 26-51 and examples 5-8 of U.S. Patent No. 5,789,203 (also US 6,060,447, US 5,595,886, and US 6,228,620). In some aspects, a B domain deleted Factor VIII has a deletion described in col. 1, lines 25 to col. 2, line 40 of US Patent No. 5,972,885; col. 6, lines 1-22 and example 1 of U.S. Patent no. 6,048,720; col. 2, lines 17-46 of U.S. Patent No. 5,543,502; col. 4, line 22 to col. 5, line 36 of U.S. Patent no. 5,171,844; col. 2, lines 55-68, figure 2, and example 1 of U.S. Patent No. 5,112,950; col. 2, line 2 to col. 19, line 21 and table 2 of U.S. Patent No. 4,868,112; col. 2, line 1 to col. 3, line 19, col. 3, line 40 to col. 4, line 67, col. 7, line 43 to col. 8, line 26, and col. 11, line 5 to col. 13, line 39 of U.S. Patent no. 7,041,635; or col. 4, lines 25-53, of U.S. Patent No. 6,458,563. In some aspects, a B domain deleted Factor VIII has a deletion of most of the B domain, but still contains amino-terminal sequences of the B domain that are essential for *in vivo* proteolytic processing of the primary translation product into two polypeptide chain, as disclosed in WO 91/09122, which is incorporated herein by reference in its entirety. In some aspects, a B domain deleted factor VIII is constructed with a deletion of amino acids 747-1638, *e.g.*, virtually a complete deletion of the B domain. Hoeben R.C., *et al.* *J.*

Biol. Chem. 265 (13): 7318-7323 (1990), incorporated herein by reference in its entirety. A B domain deleted Factor VIII can also contain a deletion of amino acids 771–1666 or amino acids 868-1562 of factor VIII. Meulien P., *et al.* *Protein Eng.* 2(4): 301-6 (1988), incorporated herein by reference in its entirety. Additional B domain deletions include, *e.g.*: deletion of amino acids 982 through 1562 or 760 through 1639 (Toole *et al.*, *Proc. Natl. Acad. Sci. U.S.A.* (1986) 83, 5939-5942)), 797 through 1562 (Eaton, *et al.* *Biochemistry* (1986) 25:8343-8347)), 741 through 1646 (Kaufman (PCT published application No. WO 87/04187)), 747-1560 (Sarver, *et al.*, *DNA* (1987) 6:553-564)), 741 through 1648 (Pasek (PCT application No.88/00831)), 816 through 1598 or 741 through 1689 (Lagner (Behring Inst. Mitt. (1988) No 82:16-25, EP 295597)), each of which is incorporated herein by reference in its entirety.

[0186] In other aspects, BDD FVIII includes a FVIII polypeptide containing fragments of the B-domain that retain one or more N-linked glycosylation sites, *e.g.*, residues 757, 784, 828, 900, 963, or optimally 943, which correspond to the amino acid sequence of the full-length FVIII sequence. Examples of the B-domain fragments include 226 amino acids or 163 amino acids of the B-domain as disclosed in Miao, H.Z., *et al.*, *Blood* 103(a): 3412-3419 (2004), Kasuda, A, *et al.*, *J. Thromb. Haemost.* 6: 1352-1359 (2008), and Pipe, S.W., *et al.*, *J. Thromb. Haemost.* 9: 2235-2242 (2011) (*e.g.*, the first 226 amino acids or 163 amino acids of the B domain are retained). In still other aspects, BDD FVIII further comprises a point mutation at residue 309 (from Phe to Ser) to improve expression of the BDD FVIII protein. See Miao, H.Z., *et al.*, *Blood* 103(a): 3412-3419 (2004). In still other aspects, the BDD FVIII includes a FVIII polypeptide containing a portion of the B-domain, but not containing one or more furin cleavage sites (*e.g.*, Arg1313 and Arg 1648). See Pipe, S.W., *et al.*, *J. Thromb. Haemost.* 9: 2235-2242 (2011). The references are incorporated herein by reference, and each of the foregoing deletions can be made in any Factor VIII sequence.

[0187] In certain aspects, FVIII includes a single chain FVIII polypeptide. In one embodiment, a single chain FVIII polypeptide can include one or more mutations or substitutions at R1645 or R1648 corresponding to full-length Factor VIII sequence or both. Additional examples of single chain FVIII polypeptides can be found at U.S. Provisional Application No. 61/668,889, filed July 6, 2012, which is incorporated herein by reference in its entirety. In another embodiment, a single chain FVIII polypeptide contains a FVIII polypeptide having a deletion of R1645 and/or R1648 corresponding to full-length FVIII sequence or a sequence containing R1645 and/or R1648 corresponding to full-length FVIII. For example, a single chain

FVIII can contain a deletion of amino acid positions 746 to 1649, 746 to 1652, 746 to 1655, 758 to 1649, 758 to 1652, 758 to 1655, 765 to 1649, 765 to 1652, 765 to 1655, 748 to 1658, 755 to 1658, 762 to 1658, 769 to 1658, 776 to 1658, or 783 to 1658 corresponding to full-length FVIII sequence. Additional examples can be found at U.S. Patent No. 7,041,635, filed January 3, 2003, which is incorporated herein by reference in its entirety.

[0188] A great many functional Factor VIII variants are known, as is discussed above and below. In addition, hundreds of nonfunctional mutations in Factor VIII have been identified in hemophilia patients, and it has been determined that the effect of these mutations on Factor VIII function is due more to where they lie within the 3-dimensional structure of Factor VIII than on the nature of the substitution (Cutler *et al.*, Hum. Mutat. 19:274-8 (2002), incorporated herein by reference in its entirety). In addition, comparisons between Factor VIII from humans and other species have identified conserved residues that are likely to be required for function (Cameron *et al.*, Thromb. Haemost. 79:317-22 (1998); US 6,251,632), incorporated herein by reference in its entirety.

[0189] The human Factor VIII gene was isolated and expressed in mammalian cells (Toole, J. J., *et al.*, Nature 312:342-347 (1984); Gitschier, J., *et al.*, Nature 312:326-330 (1984); Wood, W. L., *et al.*, Nature 312:330-337 (1984); Vehar, G. A., *et al.*, Nature 312:337-342 (1984); WO 87/04187; WO 88/08035; WO 88/03558; U.S. Pat. No. 4,757,006), each of which is incorporated herein by reference in its entirety, and the amino acid sequence was deduced from cDNA. Capon *et al.*, U.S. Pat. No. 4,965,199, incorporated herein by reference in its entirety, discloses a recombinant DNA method for producing Factor VIII in mammalian host cells and purification of human Factor VIII. Human Factor VIII expression in CHO (Chinese hamster ovary) cells and BHKC (baby hamster kidney cells) has been reported. Human Factor VIII has been modified to delete part or all of the B domain (U.S. Pat. Nos. 4,994,371 and 4,868,112, each of which is incorporated herein by reference in its entirety), and replacement of the human Factor VIII B domain with the human Factor V B domain has been performed (U.S. Pat. No. 5,004,803, incorporated herein by reference in its entirety). The cDNA sequence encoding human Factor VIII and predicted amino acid sequence are shown in SEQ ID NOs:1 and 2, respectively, of US Application Publ. No. 2005/0100990, incorporated herein by reference in its entirety.

[0190] U.S. Pat. No. 5,859,204, Lollar, J. S., incorporated herein by reference in its entirety, reports functional mutants of Factor VIII having reduced antigenicity and reduced immunoreactivity. U.S. Pat. No. 6,376,463, Lollar, J. S., incorporated herein by reference in its

entirety, also reports mutants of Factor VIII having reduced immunoreactivity. US Application Publ. No. 2005/0100990, Saenko *et al.*, incorporated herein by reference in its entirety, reports functional mutations in the A2 domain of Factor VIII.

[0191] A number of functional Factor VIII molecules, including B-domain deletions, are disclosed in the following patents US 6,316,226 and US 6,346,513, both assigned to Baxter; US 7,041,635 assigned to In2Gen; US 5,789,203, US 6,060,447, US 5,595,886, and US 6,228,620 assigned to Chiron; US 5,972,885 and US 6,048,720 assigned to Biovitrum, US 5,543,502 and US 5,610,278 assigned to Novo Nordisk; US 5,171,844 assigned to Immuno Ag; US 5,112,950 assigned to Transgene S.A.; US 4,868,112 assigned to Genetics Institute, each of which is incorporated herein by reference in its entirety.

[0192] The porcine Factor VIII sequence is published, (Toole, J. J., *et al.*, Proc. Natl. Acad. Sci. USA 83:5939-5942 (1986)), incorporated herein by reference in its entirety, and the complete porcine cDNA sequence obtained from PCR amplification of factor VIII sequences from a pig spleen cDNA library has been reported (Healey, J. F., *et al.*, Blood 88:4209-4214 (1996), incorporated herein by reference in its entirety). Hybrid human/porcine Factor VIII having substitutions of all domains, all subunits, and specific amino acid sequences were disclosed in U.S. Pat. No. 5,364,771 by Lollar and Runge, and in WO 93/20093, incorporated herein by reference in its entirety. More recently, the nucleotide and corresponding amino acid sequences of the A1 and A2 domains of porcine factor VIII and a chimeric Factor VIII with porcine A1 and/or A2 domains substituted for the corresponding human domains were reported in WO 94/11503, incorporated herein by reference in its entirety. U.S. Pat. No. 5,859,204, Lollar, J. S., also discloses the porcine cDNA and deduced amino acid sequences. 6,458,563, incorporated herein by reference in its entirety assigned to Emory discloses a B-domain deleted porcine Factor VIII.

[0193] The Factor VIII (or Factor VIII portion of a chimeric polypeptide) can be at least 90% or 95% identical to a Factor VIII amino acid sequence shown in Sequence Table 2 without a signal sequence (amino acids 1 to 1438 of SEQ ID NO:2; amino acids 1 to 2332 of SEQ ID NO:6; amino acids 1 to 740 of SEQ ID NO:8; amino acids 1 to 745 of SEQ ID NO:10; or amino acids 1 to 684 of SEQ ID NO:12). The Factor VIII (or Factor VIII portion of a chimeric polypeptide) can be identical to a Factor VIII amino acid sequence shown in Sequence Table 2 without a signal sequence (amino acids 1 to 1438 of SEQ ID NO:2; amino acids 1 to 2332 of

SEQ ID NO:6; amino acids 1 to 740 of SEQ ID NO:8; amino acids 1 to 745 of SEQ ID NO:10; or amino acids 1 to 684 of SEQ ID NO:12).

[0194] The Factor VIII (or Factor VIII portion of a chimeric polypeptide) can be at least 90% or 95% identical to a Factor VIII amino acid sequence shown in Sequence Table 2 with a signal sequence (amino acids -19 to 1438 of SEQ ID NO:2; amino acids -19 to 2332 of SEQ ID NO:6; amino acids -19 to 740 of SEQ ID NO:8; amino acids -19 to 745 of SEQ ID NO:10; or amino acids -20 to 684 of SEQ ID NO:12). The Factor VIII (or Factor VIII portion of a chimeric polypeptide) can be identical to a Factor VIII amino acid sequence shown in Sequence Table 2 with a signal sequence (amino acids -19 to 1438 of SEQ ID NO:2; amino acids -19 to 2332 of SEQ ID NO:6; amino acids -19 to 740 of SEQ ID NO:8; amino acids -19 to 745 of SEQ ID NO:10; or amino acids -20 to 684 of SEQ ID NO:12).

B. Factor IX Polypeptides

[0195] "Factor IX", "FIX", "protein having FIX activity", "FIX protein", or "FIX polypeptide" as used herein, means functional Factor IX polypeptide in its normal role in coagulation, unless otherwise specified. Thus, the term Factor IX includes variant polypeptides that are functional and the polynucleotides that encode such functional variant polypeptides. Factor IX polypeptides include the human, bovine, porcine, canine, feline, and murine Factor IX polypeptides. The full length polypeptide and polynucleotide sequences of Factor IX are known, as are many functional variants, *e.g.*, fragments, mutants and modified versions. Factor IX polypeptides include full-length Factor IX, full-length Factor IX minus Met at the N-terminus, full-length Factor IX minus the signal sequence, mature Factor IX (minus the signal sequence and propeptide), and mature Factor IX with an additional Met at the N-terminus. Factor IX can be made by recombinant means ("recombinant Factor IX" or "rFIX"), *i.e.*, it is not naturally occurring or derived from plasma.

[0196] great many functional Factor IX variants are known. International publication number WO 02/040544 A3, which is herein incorporated by reference in its entirety, discloses mutants that exhibit increased resistance to inhibition by heparin at page 4, lines 9-30 and page 15, lines 6-31. International publication number WO 03/020764 A2, which is herein incorporated by reference in its entirety, discloses Factor IX mutants with reduced T cell immunogenicity in Tables 2 and 3 (on pages 14-24), and at page 12, lines 1-27. International publication number WO 2007/149406 A2, which is herein incorporated by reference in its entirety, discloses functional mutant Factor IX molecules that exhibit increased protein stability.

increased *in vivo* and *in vitro* half-life, and increased resistance to proteases at page 4, line 1 to page 19, line 11. WO 2007/149406 A2 also discloses chimeric and other variant Factor IX molecules at page 19, line 12 to page 20, line 9.

[0197] International publication number WO 08/118507 A2, which is herein incorporated by reference in its entirety, discloses Factor IX mutants that exhibit increased clotting activity at page 5, line 14 to page 6, line 5. International publication number WO 09/051717 A2, which is herein incorporated by reference in its entirety, discloses Factor IX mutants having an increased number of N-linked and/or O-linked glycosylation sites, which results in an increased half-life and/or recovery at page 9, line 11 to page 20, line 2. International publication number WO 09/137254 A2, which is herein incorporated by reference in its entirety, also discloses Factor IX mutants with increased numbers of glycosylation sites at page 2, paragraph [006] to page 5, paragraph [011] and page 16, paragraph [044] to page 24, paragraph [057]. International publication number WO 09/130198 A2, which is herein incorporated by reference in its entirety, discloses functional mutant Factor IX molecules that have an increased number of glycosylation sites, which result in an increased half-life, at page 4, line 26 to page 12, line 6. International publication number WO 09/140015 A2, which is herein incorporated by reference in its entirety, discloses functional Factor IX mutants that an increased number of Cys residues, which can be used for polymer (*e.g.*, PEG) conjugation, at page 11, paragraph [0043] to page 13, paragraph [0053].

[0198] In addition, hundreds of non-functional mutations in Factor IX have been identified in hemophilia patients, many of which are disclosed in Table 1, at pages 11-14 of International publication number WO 09/137254 A2, which is herein incorporated by reference in its entirety. Such non-functional mutations are not included in the invention, but provide additional guidance for which mutations are more or less likely to result in a functional Factor IX polypeptide.

[0199] The Factor IX (or Factor IX portion of a chimeric polypeptide) can be at least 90% or at least 95% or 100% identical to a Factor IX amino acid sequence shown in Sequence Table 2 without a signal sequence and propeptide sequence (amino acids 1 to 415 of SEQ ID NO:14), or alternatively, with a propeptide sequence, or with a propeptide and signal sequence (full length Factor IX).

[0200] Factor IX coagulant activity is expressed as International Unit(s) (IU). One IU of Factor IX activity corresponds approximately to the quantity of Factor IX in one milliliter of

normal human plasma. Several assays are available for measuring Factor IX activity, including the one stage clotting assay (activated partial thromboplastin time; aPTT), thrombin generation time (TGA) and rotational thromboelastometry (ROTEM[®]).

[0201] "Protein having FIX activity which is in its activated form," or "activated FIX protein" means the activated form of a corresponding FIX protein/polypeptide. The term "activated" in connection with an activated FIX protein/polypeptide is used according to its common meaning. For example, *in vivo*, Factor IX is produced as a zymogen, an inactive precursor. It is processed to remove a signal peptide, glycosylated and then cleaved, *e.g.*, by factor XIa or factor VIIa to produce activated FIX (FIXa), a two-chain form where the two chains are linked by a disulfide bridge. For example, activated FIX protein can be formed during the production and/or purification of a recombinant FIX protein. In one example, in a pharmaceutical FIX polypeptide compositions, the activated form of the FIX polypeptide can be considered an impurity.

C. Factor VIII and Factor IX Chimeric Polypeptides

[0202] "Chimeric polypeptide," as used herein, means a polypeptide that includes within it at least two moieties (or portions thereof such as subsequences or peptides) from different sources. Chimeric polypeptides can include two, three, four, five, six, seven, or more polypeptides or portions thereof from different sources, such as different genes, different cDNAs, or different animal or other species. Chimeric polypeptides can include one or more linkers joining the different polypeptides or portions thereof. Thus, the polypeptides or portions thereof can be joined directly or they can be joined indirectly, via linkers, or both, within a single chimeric polypeptide. Chimeric polypeptides can include additional peptides such as signal sequences and sequences such as 6His and FLAG that aid in protein purification or detection. In addition, chimeric polypeptides can have amino acid or peptide additions to the N- and/or C-termini.

[0203] In certain aspects, a chimeric polypeptide is a long-acting clotting factor. "Long-acting clotting factor" such as long-acting FVIII or long-acting FIX is a Factor VIII or Factor IX having an increased half-life (also referred to herein as $t_{1/2}$, $t_{1/2}$ beta, elimination half-life and HL) over a reference Factor VIII or a reference Factor IX, respectively. The increased half-life of a long-acting Factor VIII or a long-acting Factor IX may be due to fusion to one or more non-Factor VIII or non-Factor IX polypeptides such as, *e.g.*, Fc, XTEN, albumin, a PAS sequence, transferrin, CTP (28 amino acid C-terminal peptide (CTP) of hCG with its 4 O-glycans),

polyethylene glycol (PEG), hydroxyethyl starch (HES), albumin binding polypeptide, albumin-binding small molecules, or two or more combinations thereof. The increased half-life may be due to one or more modification, such as, e.g., pegylation. Exemplary long-acting clotting factor polypeptides include, e.g., chimeric Factor VIII polypeptides comprising Fc, chimeric Factor VIII polypeptides comprising XTEN, chimeric Factor VIII polypeptides comprising albumin, chimeric Factor IX polypeptides comprising Fc, chimeric FIX polypeptide comprising XTEN, or chimeric Factor IX polypeptide comprising albumin. Additional exemplary long-acting Factor VIII polypeptides include, e.g., pegylated Factor VIII or pegylated Factor IX.

[0204] The "reference" polypeptide, in the case of a long-acting chimeric Factor VIII polypeptide, is a polypeptide consisting essentially of the Factor VIII portion of the chimeric polypeptide, e.g., the same Factor VIII portion without the Fc portion, without the XTEN portion, or without the albumin portion. The "reference" polypeptide, in the case of a long-acting chimeric Factor IX polypeptide, is a polypeptide consisting essentially of the Factor IX portion of the chimeric polypeptide, e.g., the same Factor IX portion without the Fc portion, without the XTEN portion, or without the albumin portion. Likewise, the reference polypeptide in the case of a modified Factor VIII or Factor IX is the same Factor VIII or Factor IX without the modification, respectively, e.g., a Factor VIII without the pegylation or a Factor IX without the pegylation.

[0205] In some aspects, the chimeric polypeptide comprises a Factor VIII portion and a non-Factor VIII portion. In some aspects, the chimeric polypeptide comprises a Factor IX portion and a non-Factor IX portion. Exemplary non-Factor VIII or non-Factor IX portions include, e.g., Fc, and albumin. Exemplary chimeric polypeptides include, e.g., chimeric Factor VIII-Fc polypeptides, chimeric Factor IX-Fc polypeptides, chimeric Factor VIII-albumin polypeptides, and chimeric Factor IX-albumin polypeptides.

[0206] In some aspects, a chimeric polypeptide comprising a Factor VIII or Factor IX portion of a chimeric protein has an increased half-life ($t_{1/2}$) over a polypeptide consisting of the same Factor VIII or Factor IX portion without the non Factor VIII or Factor IX portion. A chimeric Factor VIII or Factor IX polypeptide with an increased $t_{1/2}$ can be referred to herein as a long-acting Factor VIII or Factor IX. Long-acting chimeric Factor VIII or Factor IX polypeptides include, e.g., Factor VIII or Factor IX fused to Fc (including, e.g., chimeric Factor VIII or Factor IX polypeptides in the form of a hybrid such as a FVIII-Fc monomer dimer hybrid; see e.g. Figures 1 and 2, and Table 2; and US Patent Nos. 7,404,956 and 7,348,004).

[0207] Exemplary chimeric Factor VIII polypeptides include, *e.g.*, chimeric Factor VIII-Fc polypeptides. Exemplary chimeric Factor VIII-Fc polypeptides include, *e.g.*, SEQ ID NOs:2, 6, 8, 10, and 12 (Sequence Table 2), with or without their signal sequences and the chimeric Fc polypeptide of SEQ ID NO:4 (Sequence Table 2). The chimeric polypeptide can comprise a sequence at least 90% or 95% identical to the Factor VIII and Fc amino acid sequence shown in Sequence Table 2A(i) without a signal sequence (amino acids 1 to 1665 of SEQ ID NO:2) or at least 90% or 95% identical to the Factor VIII and Fc amino acid sequence shown in Sequence Table 2A(i) with a signal sequence (amino acids -19 to 1665 of SEQ ID NO:2). The chimeric polypeptide can comprise a sequence identical to the Factor VIII and Fc amino acid sequence shown in Sequence Table 2A(i) without a signal sequence (amino acids 1 to 1665 of SEQ ID NO:2) or identical to the Factor VIII and Fc amino acid sequence shown in Sequence Table 2A(i) with a signal sequence (amino acids -19 to 1665 of SEQ ID NO:2).

[0208] Exemplary chimeric Factor IX polypeptides are Factor IX-FcRn BP chimeric polypeptides, *e.g.*, Factor IX-Fc chimeric polypeptides such as the FIXFc in SEQ ID NO:2 (Sequence Table 2), with or without its signal sequence and propeptide. Other exemplary chimeric polypeptides include, but are not limited to, Factor IX-XTEN chimeric polypeptides. Factor IX can be fused to either N-terminus or C-terminus of XTEN. The chimeric polypeptide can comprise a sequence at least 90% or at least 95% or 100% identical to the Factor IX and FcRn BP, *e.g.*, the Fc amino acid sequence shown in Sequence Table 2A without a signal sequence and propeptide sequence (amino acids 1 to 642 of SEQ ID NO:14), or alternatively, with a propeptide sequence, or alternatively with a signal sequence and a propeptide sequence.

D. Factor VIII and Factor IX Hybrid Polypeptides

[0209] "Hybrid" polypeptides and proteins, as used herein, means a combination of a chimeric polypeptide with a second polypeptide. The chimeric polypeptide and the second polypeptide in a hybrid can be associated with each other via non-covalent protein-protein interactions, such as charge-charge or hydrophobic interactions. The chimeric polypeptide and the second polypeptide in a hybrid can be associated with each other via covalent bond(s) such as disulfide bonds. The chimeric peptide and the second peptide can be associated with each other via more than one type of bond, such as non-covalent and disulfide bonds. Hybrids are described in WO 2004/101740, WO2005/001025, US Pat. No. 7,404,956, US Pat. No. 7,348,004, and WO 2006/074199, each of which is incorporated herein by reference in its entirety. The second

polypeptide can be a second copy of the same chimeric polypeptide or it can be a non-identical chimeric polypeptide.

[0210] In some aspects, the second polypeptide is a polypeptide comprising an Fc. In some aspects, the chimeric polypeptide is a chimeric Factor VIII-Fc polypeptide and the second polypeptide consists essentially of Fc, e.g, a rFVIII-Fc recombinant fusion protein consisting of a single molecule of recombinant B-domain deleted human FVIII (BDD-rFVIII) fused to the dimeric Fc domain of the human IgG1, with no intervening linker sequence. This hybrid polypeptide is referred to herein as FVIII-Fc monomeric Fc fusion protein, FVIII-Fc monomer hybrid, monomeric FVIII-Fc hybrid, and FVIII-Fc monomer-dimer. In some aspects, the chimeric polypeptide is a Factor IX-FcRn BP, e.g., Factor IX-Fc chimeric polypeptide, and the second polypeptide consists essentially of Fc. See, e.g., Sequence Table 2 (SEQ ID NOs:14 and 4). See, e.g., US 7404956, which is incorporated herein by reference in its entirety.

[0211] The second polypeptide in a hybrid can comprise or consist essentially of a sequence at least 90% or at least 95%, or 100% identical to the amino acid sequence shown in Sequence Table 2 without a signal sequence (amino acids 1 to 227 of SEQ ID NO:4), or alternatively, at least 90%, or at least 95% , or 100% identical to the amino acid sequence shown in Table 2 with a signal sequence (amino acids -20 to 227 of SEQ ID NO:4).

[0212] Having now described the present invention in detail, the same will be more clearly understood by reference to the following examples, which are included herewith for purposes of illustration only and are not intended to be limiting of the invention. All patents and publications referred to herein are expressly incorporated by reference in their entireties.

Examples

MATERIALS AND METHODS

Preparation of Test Strips (FVIII)

[0213] Disposable strips were the same type as currently used in Coag-Sense™ PT/INR Monitoring System (CoaguSense, Inc, Fremont, California) without the Prothrombin Time reagents added to the strip. Strips were coated with 1.25 µL of 80% of 0.1mg/mL purified Factor IXa (obtained from Haematologic Technologies, Essex Junction, Vermont) plus 20% phospholipid vesicles prepared as described below. Strips were air dried in a dry 37°C incubator and individually sealed in plastic pouches containing a desiccant.

Preparation of Phospholipids

[0214] The strip for the Standard FMS Factor VIII assay used an equal mix of Phospholipid Blend 2 and Phospholipid Blend 8. Phospholipid Blend 2 consisted of a phosphatidylcholine (PC) and phosphatidylserine (PS) mixture at a 70:30 molar ratio (mol-%). Phospholipid Blend 8 consisted of a PC, PS and phosphatidylglycerol (PG) mixture at a 80:10:10 molar ratio. Thus, the optimized ratio of PL on the Standard FMS Factor VIII assay strip ("standard strip") was 75:20:5 (PC:PS:PG).

[0215] To prepare phospholipid blends, a total of 2.6 μ moles of phospholipids dissolved in chloroform was dispensed into a glass tube, where individual phospholipids were mixed at the defined molar ratio (synthetic phospholipids can be obtained from Avanti Polar Lipids, Alabaster, Alabama). The phospholipid mixture was dried in a fume hood under a gentle stream of nitrogen or argon. When dry, phospholipid mixtures were dried in a speed-vac for an additional 1 hour to overnight under high vacuum to remove any residual chloroform. 2.6 mL HEPES Buffered Saline (10 mM HEPES pH 7.4 and 140 mM NaCl) at room temperature were added to the dried-down phospholipid mixture until all the dried lipid suspension was re-hydrated. The tube was incubated at 37°C and vortexed intermittently. The result was a milky, uniform suspension. Small unilamellar vesicles were prepared by sonication for 7-10 minutes on ice with one-minute gap intervals between the shocks. The residual large vesicles were removed by filtering using 45-micron filters.

Test procedure

[0216] The test strip containing the dried activator mixture (FIXa/PL mixture) was pre-warmed automatically after insertion into the measuring device. When the device was ready to receive a sample, patient plasma or whole blood was recalcified with 0.3 volumes of 60 mM CaCl_2 and 12 μ L of the recalcified sample were immediately added to the well of the pre-warmed test strip. Clot formation was initiated as the blood/plasma dissolved the dried activator on the test strip. The device measured the time from initiation to formation of a clot with defined characteristics. This time interval was referred to as clotting time (Ct). See, e.g., FIG. 3 for an example of the application of the Standard FMS Factor VIII assay.

[0217] Further optimization of the FMS FVIII assay included the addition of trace amounts of Factor VIII (approx. 1% of normal) to the dried activator mixture, which resulted in a

base clot time, rather than “timing out” in the absence any clot formation in severely hemophilic patient samples. Further optimization of the FMS FVIII assays will include adding CaCl₂ on the dried test strip rather than off-strip recalcification of the sample.

[0218] Optimized FMS FVIII assay chemistry during the clot reaction can contain the following reactants (i) 9.2 μL patient blood; (ii) 2.8 μL buffer; (iii) 14 mM CaCl₂; (iv) 21 μM phospholipid mix (PC:PS:PG at 75:20:5); (v) 8.3 μg Factor IXa; and (vi) 24 pg Factor VIII.

FMS Factor IX assay

[0219] The FMS Factor IX assay (see, *e.g.*, FIG. 4 for an example of the application of the Standard FMS Factor IX assay) followed the same procedure as for Factor VIII, except that (i) the activator mixture included on the test strip contains Factor XIa instead of Factor IXa (the exact amount of Factor XIa needed varied depending on the specific activity of this reagent and is titrated for optimal amount); and, (ii) trace amounts of Factor IX could optionally be added to the strip to achieve a base clotting time to improve responsiveness to small amounts of Factor IX in the patient sample.

Example 1: Standard Factor Monitoring System (FMS) Assay

[0220] Both Standard FMS assays (Standard FMS Factor VIII assay and Standard FMS Factor IX assay) were initiated by the application of 12 μL of recalcified patient plasma directly to the test bed, a disposable test strip containing activated coagulation factor-phospholipid complex. On this test bed, utilizing linear log-log curve fitting of concentration versus clotting time, both Standard FMS assays performed well when an individual Hemophilia A or Hemophilia B donor plasma was spiked with either rFVIII_{Fc} or rFIX_{Fc}, respectively (TABLE 1).

TABLE 1: Application of Standard FMS Factor VIII and Factor IX assays to Hemophilia A and Hemophilia B Samples spiked with either rFVIII_{Fc} or rFIX_{Fc}, respectively.

	Standard FMS Factor VIII Assay	Standard FMS Factor IX Assay
Assay Range (IU/dL)	0.8 – 100	0.2 – 100
Accuracy (% Spike Recovery)	+/- 10%	+/- 10.1
Precision (% CV)	3.8	1.9

Example 2: Sensitivity of the Standard FMS assay to Individual Phenotypic Variability

[0221] The disclosed "Standard FMS" assay system utilized undiluted patient plasma, thus, it was more analogous to an aPTT assay than to the one-stage factor assay. In the laboratory aPTT assay, one part undiluted patient plasma is generally combined with equal parts of liquid aPTT reagent and of CaCl₂ solution. In contrast, in the one-stage assay, one part diluted (1:5) patient plasma is generally combined with one part factor deficient plasma, one part aPTT reagent, and one part CaCl₂. Because of this dilution of patient plasma with factor deficient plasma, the one stage factor assay largely masks inter-subject variability that can occur as a result of variable levels of non-target coagulation factors (TABLE 2).

TABLE 2: Hemophilia Donor Phenotypic Variability

VIII Deficient Plasma Samples											
Sample	PT (sec)	APTT (sec)	Fib. (mg/dL)	% II	% V	% VII	% VIII	% IX	% X	% XI	% XII
HRF 11P2F8	11.1	104.8	293	85	86	80	< 1	86	107	79	85
HRF 11P3F8	11.2	> 400	353	82	76	95	< 1	98	95	82	87
GK 892-2086	11.6	103.0	248	78	67	81	< 1	76	93	80	126
HRF 10-389	11.2	117.2	276	78	94	72	< 1	74	93	62	80
HRF 10-1081	10.8	> 400	334	89	116	80	< 1	113	122	100	92
BD-001	11.0	70.2	293	In89	92	75	2.2	90	97	90	121
BD1-002	11.3	111.3	345	92	90	55	< 1	120	125	99	120
BD1-005	10.4	91.4	342	99	98	84	< 1	128	132	115	105
BD-00X	10.7	76.3	236	94	75	91	< 1	102	101	83	85

IX Deficient Plasma Samples											
Sample	PT (sec)	APTT (sec)	Fib. (mg/dL)	% II	% V	% VII	% VIII	% IX	% X	% XI	% XII
HRF 11P1F9	12.0	105.6	383	85	111	57	91	2	114	94	110
HRF 09-860	12.9	82.6	226	89	88	43	63	2	115	80	77
HRF 11-019	11.7	106.8	387	82	111	60	101	2	114	105	113
GK 929-2074	11.8	113.1	357	85	113	58	94	2	117	97	105
GK 939-2054	12.1	97.8	257	89	96	53	72	2	130	79	89

[0222] Chromogenic based Factor VIII and Factor IX assays are also insensitive to non-target coagulation factors because of the large sample dilutions and physiologically irrelevant concentrations of added coagulation factors and inhibitors.

[0223] To assess the sensitivity of the Standard FMS assay to individual phenotypic variability, four plasma samples collected from individual hemophilia A (HemA) donors after 5

day washout period (essentially 0% Factor VIII, confirmed by in-house assays) were spiked at 6 levels of rFVIII_{Fc} (100%, 50%, 25%, 12.5%, 6.3%, 3.1%) and the clotting time was determined using the Standard FMS Factor VIII assay. The Standard FMS assay was applied using no equilibrating factors, and activation mixture comprising FIXa and Phospholipid Blend 2 (FIG. 5A) or Phospholipid Blend 8 (FIG. 5B). Although log-linear plots of rFVIII_{Fc} concentration versus clot time for the 4 individuals displayed the same assay range and sensitivity, each of the individuals displayed a unique dose response to added rFVIII_{Fc}.

Example 3: Alternate FMS Assay

[0224] To eliminate the observed phenotypic variability, several modifications to the Standard FMS methodology were investigated. Substitution of less sensitive phospholipid blends was able to reduce phenotypic variability. Adding a variety of purified coagulation factors, *e.g.*, Factors II, VII, VIII, IX, X, XI, XII, XIII, fibrinogen, vWF and Tissue Factor, and inhibitors, *e.g.*, CTI, aprotinin, ε-aminocaproic acid (EACA), D-Phenylalanyl-L-prolyl-L-arginine chloromethyl ketone-Factor VIIa (FPRCK-FVIIa), or anti-FVIII monoclonal antibodies, also was able to reduce phenotypic variability.

[0225] A variant of the Standard FMS was developed. This variant, referred to as the "Alternate FMS" assay throughout the instant disclosure was essentially designed as a hybrid between the "Standard FMS" assay and a one stage coagulation factor assay. The Alternate FMS assay also utilized an activation mixture comprising activated coagulation factor (FIXa or FXIa) combined with a phospholipid vesicle preparation and dried on the solid substrate (*e.g.*, a disposable test strip). In the plasma based Alternate FMS assay (see FIGS. 6A and 6B), one part hemophilia plasma spiked with either rFVIII_{Fc} or rFIX_{Fc} was mixed with three parts of a substrate plasma that had been depleted of the assay target factor. In this manner, the variability of non-target plasma components was normalized by addition of the substrate plasma.

[0226] This combination of hemophilia plasma and substrate plasma was done in an all-liquid system resulting in a four-fold dilution of the hemophilia test plasma, thus increasing the lower level of detection.

TABLE 3: Range, average precision and accuracy data for Alternate FMS Factor VIII and Factor IX Assays

	Alternate FMS	Alternate FMS
--	---------------	---------------

	Factor VIII Assay	Factor IX Assay
Range (IU/dL)	1.5 - 100	0.4 – 100
Average Precision (%CV)	1.8%	1.0%
Accuracy (% Spike Recovery)	+/- 10.2	+/- 11.3

[0227] It is anticipated that preparing a dry substrate plasma format will significantly improve the lower level of detection, since the target analyte will be four-fold higher than in the current format.

Example 4: Evaluation of Inter-Subject Variability Using the Alternate FMS Assay

[0228] To evaluate the ability of the Alternate FMS assay format to decrease inter-subject variability, 14 hemophilia A and 9 hemophilia B plasma samples were procured to conduct spike recovery studies. Plasma samples were obtained from 4 different vendors, collected by 3 different methodologies on 3 different anticoagulants. Plasma samples included immunodepleted as well as congenital hemophilia plasma. Plasma samples were also subjected to different storage conditions as well as freeze thaw cycles. The effect of a single plasma freeze thaw cycle on Alternate FMS assay performance is shown in FIGS. 7A (Alternate FMS Factor IX assay) and 7B (Alternate FMS Factor VIII assay).

[0229] In each case, samples contained 12 μ L of re-calcified plasma mixed 1:3 with substrate plasma (Factor IX deficient plasma supplemented with defined levels of rFIXFc in the Alternate FMS Factor IX assay; and Factor VIII deficient plasma supplemented with defined levels of rFVIII Fc in the Alternate FMS Factor VIII assay). The results of the spike recovery studies are summarized in FIGS. 8A and 8B.

[0230] The samples presented in FIG. 8A were citrated plasma samples collected from 14 hemophilia A donors (assumed <1% Factor VIII). Plasma samples were collected at 3 sites, using 3 different methodologies and spiked with varying levels of rFVIII Fc. Each of these samples was also assayed on a laboratory reference system (MLA-1000 Coagulation Analyzer) utilizing the manufacturer's suggested reagents and calibration standard plasma traceable to the appropriate WHO standard. For hemophilia A plasmas spiked with rFVIII Fc, the theoretical values (assuming Factor VIII plasma levels supplied by vendors) were not in good agreement with values determined on the MLA. This could be related to sample quality issues, errors in the

MLA assay, or errors in stock Factor VIII concentrations. For this reason, spike recovery assays for Alternate FMS Factor VIII assay in FIG. 8A were plotted as MLA value vs. Alternate FMS Factor VIII assay value (FIG. 8A). The dashed lines on the graph represented +/- 20% of the MLA determined Factor VIII level. The average CV for all the Alternate FMS Factor VIII assays performed on the 14 hemophilia A donors was 3.1.

[0231] The samples presented in FIG. 8B were citrated plasma samples collected from 9 hemophilia B donors (8 donors were <1% Factor IX; 1 donor was ~34% Factor IX). Plasma samples were collected at 3 sites, using 3 different methodologies and spiked with varying levels of rFIXFc. Each of these samples was also assayed on a laboratory reference system (MLA-1000 Coagulation Analyzer) utilizing the manufacturer's suggested reagents and calibration standard plasma traceable to the appropriate WHO standard. Factor IX values and MLA values were in good agreement. Assuming the MLA value was the "true value," a plot was constructed of MLA factor concentration versus Alternate FMS Factor IX assay concentrations (FIG. 8B). The dashed lines on the graph represented +/- 20% of the MLA determined Factor IX level. The average CV for the 64 determinations on 8 different instruments was 3.1% (range 0-10.2%). There was no apparent bias over the range of Factor IX concentrations (1.5-12.5 IU/dL) tested.

[0232] Assuming that the concentration determined by the MLA assay was the true value, then 61% of the Alternate FMS Factor VIII determinations and 75% of the Alternate FMS Factor IX determinations were within a +/- 20% accuracy range. The average spike recovery for the Alternate FMS Factor VIII assay was +/- 21% (Range 0.8-51%) and for the Alternate FMS Factor IX assay it was +/- 23% (Range 0.3 - 98%). Assay performance was remarkable considering the non-ideal nature of the frozen plasma samples, uncertainties surrounding stock concentrations of rFVIII and rFIX products, not yet optimized test bed parameters, manual solid substrate production, and non-standardized "off the shelf" critical raw materials.

Example 5: Adaptation of Alternate FMS Assay to Whole Blood Samples

[0233] The feasibility of adapting these Alternate FMS assays to whole blood was examined in normal donors and in hemophilia A (n=4) (results shown in Example 5.1) and hemophilia B (n=1) subjects (results shown in Example 5.2).

[0234] The experimental protocol was similar for each round of testing using Alternate FMS Factor VIII and Factor IX assays. In both cases, subjects were asked to suspend factor replacement therapy for a minimum of 4 days prior to the test date. Citrated venous whole blood

and fingerstick whole blood samples were collected prior to patient self-administration of their individual routine replacement therapy. A second set of citrated venous whole blood and fingerstick whole blood samples were collected and tested 20-40 minutes post infusion. Fingerstick samples, pre and post infusion were applied directly to the FMS test bed (solid substrate containing activation mixture). Aliquots of pre-infusion citrated venous blood samples were spiked with varying levels of the appropriate drug product (either rFVIII_{Fc} or rFIX_{Fc}) and then assayed using the Alternate FMS assay. Samples were also tested on the MLA system.

Example 5.1.: Adaptation of Alternate FMS Factor VIII Assay to Whole Blood Samples

[0235] The Alternate FMS Factor VIII assay was applied to six hemophilia A subjects. The results of the last 2 test events are summarized in FIGS. 9-14 and TABLES 4 and 5. A direct comparison of the data in FIGS. 9-12 and FIG. 14 test data cannot be made owing to reagent lot changes. The major goal of the testing was to determine the feasibility of the Alternate FMS assay to mute the inter-subject variability inherent in the Standard FMS assay in whole blood samples from hemophilia A donors as it did in frozen plasma samples.

[0236] FIGS. 9A and 9B summarize an experiment in which citrated venous and fingerstick whole blood samples were collected from 2 hemophilia A subjects 5 days pre and post infusion treatment with factor replacement therapy. Samples were spiked with increasing concentrations (0 IU/dl to 200 IU/dL) of rFVIII_{Fc} and tested utilizing the Standard FMS standard and Alternate FMS assays. Assuming both subjects' baseline FVIII values were 0 IU/dL, then the 2 hemophilia A subjects displayed disparate dose response in the Standard FMS assay. This was likely due to inter-subject variability in coagulation factors other than FVIII or to cellular components. When these same samples were run using the Alternate FMS assay, both subjects displayed similar concentration dependent clot times over the range of 1.5–200 IU/dL rFVIII_{Fc}.

[0237] Each of the venous whole blood samples from the spike experiments described above was centrifuged to prepare plasma samples. The frozen plasma retentions were subsequently assayed on the MLA system (FIGS. 10A, 10B and 10C), using the Standard FMS Factor VIII assay (FIGS. 11A and 11B), and using the Alternate FMS Factor VIII assay (FIGS. 12A and 12B) to ascertain the relationship between FMS whole blood clot times versus plasma clot times. The trends in dose response for plasma samples mirrored those of venous whole blood samples (see FIG. 13) indicating a correlation that can be exploited for calibration purposes.

Example 5.2: Application of the Alternate FMS Factor VIII Assay to Citrated and Non-Citrated Whole Blood Samples

[0238] Since the ultimate goal for the FMS assays was to use fingerstick whole blood that was not citrate anticoagulated, a comparison between citrated venous blood, citrated plasma and non-citrated fingerstick blood was performed in parallel to the previously described experiment. The results of this comparison are summarized in TABLE 4. Fingerstick whole blood samples displayed concentration-dependent clotting analogous to venous blood and plasma samples in both the Standard and the Alternate FMS methods.

TABLE 4: FMS FVIII Assays - Plasma/Venous/Fingerstick Blood Sampling Correlation

	Standard FMS		Alternate FMS	
	Factor VIII Assay		Factor VIII Assay	
DONOR ID	003	005	003	005
Pre-Dose (<1% FVIII)	Clot Time (seconds)			
Venous	>300	>300	116.5	112.6
Fingerstick	>300	>300	ND	ND
Plasma	>300	>300	102.6	104.9
Venous +100% rFVIII-Fc Spike	61.5	55.2	77.8	76.3
Plasma + 100% rFVIII-Fc Spike	45.8	46.5	64.4	64
Post-Dose (assume 100% FVIII)				
Venous	65	56.1	89.1	83.6
Fingerstick	54.7	48.6	71.1	ND
Plasma	52.9	47	72.2	70.4

ND=Not determined

[0239] Two additional Hemophilia A donors were tested using essentially the same protocol with the following changes: (i) testing focused mainly on the Alternate FMS assay, (ii) new lots of strips and raw materials, including substrate plasma, were used in this testing, and (iii) a modified fingerstick protocol using a high flow pediatric lancet was employed. Also, plasma samples separated from the citrated venous blood were assayed prior to freezing and retesting. Samples were spiked with increasing levels (0.8–200 IU/dL) rFVIII-Fc prior to assay.

[0240] The results of this second round of testing are displayed in FIGS. 14A and 14B, and TABLE 5. General assay performance was improved in these tests compared with the results from the previous round of testing shown in TABLE 4.

TABLE 5: Alternate FMS Factor VIII Assay - Plasma/Venous/Fingerstick Blood Sampling Correlation

DONOR ID	Alternate Method	
	BD1-002	BD1-004
Pre-Dose Samples	CLOT TIME (seconds)	
Venous Blood	>300	>300
Fingerstick Blood	>300	>300
Plasma	>300	>300
Venous + 100% rFVII -Fc Spike	56.7	57.4
Plasma + 100% rFVIII-Fc Spike	60.0	57.9
Post Dose Samples		
Venous Blood	54.9	59.9
Fingerstick Blood Drop 1	53.6	55.1
Drop 2	57.7	61.7
Plasma, Neat	58.5	ND

[0241] Results indicated that, in the current format, the useful range for the Alternate FMS Factor VIII assay in venous blood is 1.5 IU/dL-200 IU/dL. The average CV for all of these determinations (n=17) was 2.1% (range 0.3–4.8) with no trend in CV with level of FVIII. As it was designed to do, the Alternate FMS Factor VIII assay displayed minimized intersubject variability thought to result from natural variations in non-Factor VIII effectors.

[0242] It is anticipated that optimization of instrument parameters to improve clot detection at the lower (<1%) range will expand the useful range of the assay to <0.5 IU/dL. Limited data on fingerstick whole blood indicated a good correlation to citrated whole blood and plasma. Experiments that follow temporal FMS fingerstick assays on post factor replacement therapy will be used to explore useful range for this format.

Example 5.3.: Adaptation of Alternate FMS Factor IX Assay to Whole Blood Samples

[0243] The utility of the Alternate FMS Factor IX assay in whole blood samples was demonstrated by performing experiments analogous to those described for Factor VIII on a Hem B subject. The Hem B subject suspended Factor IX replacement therapy for 4 days prior to the test date. Citrated venous whole blood, citrated plasma, and fingerstick whole blood samples were collected pre- and post-self administration of the subject’s routine Factor IX replacement therapy.

[0244] Aliquots of pre-infusion venous blood were spiked with increasing levels of rFIXFc (0– 200IU/dL) for use in constructing dose-response curves using the Alternate FMS Factor IX assay. Plasma samples separated from these samples were assayed fresh using the Alternate FMS IX assay. Frozen retentions were subsequently assayed using the Alternate FMS Factor IX assay and the MLA reference system. The results from these experiments are summarized in FIGS. 15A and 15B, and TABLE 6. The average CV for the 44 determinations performed on 8 random instruments was 1.7%. The range of CV values (0-5.8%) did not appear correlated to Factor IX levels.

[0245] The potential range in whole blood as demonstrated by the venous blood dose-response curves was 0.4 IU/dL – 100 IU/dL with an average CV of 1.8%. Again, CVs were not significantly different over the entire range of the assay.

TABLE 6: Alternate FMS Factor IX Assay - Plasma/Venous/Fingerstick Blood Sampling Correlation

	Alternate Method Factor IX Assay
DONOR ID	BD2-002
Pre-Dose Samples	Clot Time (seconds)
Venous Blood	90.4
Fingerstick Blood	103.5
Plasma	107.6

Venous + 100% rFVIII-Fc Spike	52.2
Plasma + 100% rFVIIIFc Spike	53.8
Post Dose Samples	
Venous Blood	54.1
Fingerstick Blood	62.8
Plasma, Neat	63.4

Example 6: Evaluation of Instrument-to-Instrument Variability

[0246] This experiment used 8 instruments in random order for 64 determinations using the Hem A samples used in Example 4. Instrument to instrument variability was evaluated by assaying a single Factor VIII deficient plasma sample spiked to 100% and 3% rFVIIIFc in duplicate on 16 research instruments (FIG. 16). The observed CV values for the 100% spike (1.7%) and the observed CV value for the 3% spike (3.8%) were exceptional in light of the fact that no tuning was done on those instruments and the results included inter-instrument results.

Example 7: Factor Monitoring vs. PK Determination vs. Global Hemostasis Test

[0247] Accurate clotting factor level determination in patients is a technical challenge. Several approaches can be use, e.g., factor monitoring, pharmacokinetics (PK) determination, or using a global hemostasis test.

[0248] Factor monitoring can be accomplished by routine measurement of Factor VIII or Factor IX levels by finger stick at treatment center and/or at the patient's home. This approach has some advantages, e.g., it can be used for determining "traditional" PK (recovery, clearance, terminal $t_{1/2}$, etc.), it allows long-term use by the patient or caregiver to evaluate coverage at any given time, patients and health care providers are familiar with the concept of using factor levels for dosing (or the concept is easy to adopt), and it can be used for any current Factor VIII or Factor IX products anywhere ("lab access" in developing countries, diagnostic tool). The main

drawback of this approach is that it requires high accuracy and precision, which makes it the most technically challenging approach. This is due, among other factor, to high inter-patient variability of coagulation time at equivalent factor levels, which needs to be "equilibrated" or alternatively can require one-time patient-specific calibration (*e.g.*, single lab measurement during training visit).

[0249] If using PK determination, the readout is clot time only; thus, it does not provide actual clotting factor levels. The main advantages of this approach are that it requires precision only, since accuracy for factor levels is not needed, and no patient-specific calibration needed. In general, home-use with 5-8 measurements is likely to provide more accurate PK than 1-2 laboratory tests. This approach is also less technically challenging than factor monitoring because inter-patient variability in coagulation is not relevant for calculation of terminal $t_{1/2}$, high precision and linearity of dose response have been shown for plasma, and proof of Concept for device chemistry has been achieved. The main drawbacks of this approach are (i) lack of transparency for dose determination based on clot time, and (ii) long-term use by subject requires adoption of "global hemostasis" concepts, *e.g.*, "Minimal clot time needed for individual hemostasis" (however, these concepts can be intuitive: "If your blood does not clot in 90 sec, you need more factor").

Determining Factor Level from Clot Time (Ct)

[0250] FIG. 17 exemplifies the use of clotting time measurements from FMS assays to determine factor levels. FMS assay results showed a linear relationship between Ct and factor levels, which can be represented according to Equation 1:

$$Ct = A \times \ln(\%Factor) + B \quad [\text{Equation 1}]$$

where the slope A was similar for all patients, at the offset B was due to patient-specific global coagulation differences.

[0251] It is possible to optimize the chemistry of the FMS assay (*e.g.*, test strip design) to eliminate B, so there is no patient-specific offset. This approach can be used to design "ready to use" factor monitoring devices that do not require patient-specific calibration. Alternatively, the factor monitoring device can be customized for each patient by calculating B for each patient and configuring the monitoring device accordingly.

Determining Dosing Regimen based on Clot Time (Ct)

[0252] FIG. 18 exemplifies how dosage regimens can be determined based on clotting time (Ct) determined using an FMS assay and data from population modeling, *e.g.*, based on the A-LONG rFVIII Fc clinical trial (ClinicalTrials.gov Identifier NCT01181128) or the B-LONG rFIX Fc clinical trial (ClinicalTrials.gov Identifier NCT01027364).

[0253] Half-life (HL) in terminal phase of PK can be determined according to the following set of equations:

$$Ct_1 = A \times \ln(\%F_1) + B \quad [\text{from Equation 1}]$$

$$Ct_2 = A \times \ln(\%F_2) + B \quad [\text{from Equation 1}]$$

$$HL = -0.693 \times (T_2 - T_1) / \ln(\%F_1 / \%F_2) \quad [\text{Equation 3}]$$

hence:

$$HL = -0.693 \times (T_2 - T_1) \times A / (Ct_1 - Ct_2) \quad [\text{Equation 4}]$$

where A is the slope, a device-specific parameter which would be the same for all patients. Note that the "offset" (B) becomes irrelevant, *i.e.*, inter-patient differences in global coagulation do not affect terminal half-life.

[0254] Population modeling based on clinical trials can be used to calculate product-specific *in vivo* recovery and α -phase half-life (distribution phase half-life), which in turn can be used to calculate "time to trough." FMS assay derived patient-specific half-life values and "time to trough" values can in turn be used to calculate patient-specific dose and dose interval.

Global Hemostasis Test based on FMS Assay

[0255] The FMS assays described above have been used to develop a global hemostasis test. The FMS assays disclosed herein measure an individual's overall clotting potential at any given level of coagulation factor. Proof of concept, sensitivity and range of the FMS assays have been established as shown in the examples above. Furthermore, no external dilution is performed as there is no need to equilibrate patient-specific differences.

[0256] As shown above in Equation 3, an increase in Ct as clotting factor is cleared over time correlates with terminal half-life (HL). Individual clot time at trough ($C_{t\text{trough}}$) is a critical parameter to establish in each patient. With known patient-specific HL and $C_{t\text{trough}}$, the "time to trough" (T) after any measured Ct is then predictable and can be calculated according to the following formula:

$$T \approx -1.44 \times HL / (A \times (C_{t\text{measured}} - C_{t\text{trough}})) \quad [\text{Equation 5}]$$

The time to trough (T) would correspond to the time to the next dose.

Conclusions

[0257] If the primary purpose of the application of the FMS assay is to define the initial dosing regimen, a precise readout of clot time is sufficient. There is no need for accuracy or patient-specific calibration for terminal $t_{1/2}$. To determine other PK parameters (*e.g.*, recovery and clearance) in individual patients, accurate factor levels are required, however.

[0258] "Minimal clot time needed for hemostasis" can be an important biomarker for the individual patient. Once the FMS assay has been applied to measure (i) individual Ct at trough and (ii) change in Ct over time (*i.e.*, individual terminal PK), estimating the "time to trough" (time to next dose) based on a single Ct measurement is expected to be very accurate.

[0259] It is to be appreciated that the Detailed Description section, and not the Summary and Abstract sections, is intended to be used to interpret the claims. The Summary and Abstract sections can set forth one or more but not all exemplary aspects of the present invention as contemplated by the inventor(s), and thus, are not intended to limit the present invention and the appended claims in any way.

[0260] The present invention has been described above with the aid of functional building blocks illustrating the implementation of specified functions and relationships thereof. The boundaries of these functional building blocks have been arbitrarily defined herein for the convenience of the description. Alternate boundaries can be defined so long as the specified functions and relationships thereof are appropriately performed.

[0261] The foregoing description of the specific aspects will so fully reveal the general nature of the invention that others can, by applying knowledge within the skill of the art, readily modify and/or adapt for various applications such specific aspects, without undue

experimentation, without departing from the general concept of the present invention. Therefore, such adaptations and modifications are intended to be within the meaning and range of equivalents of the disclosed aspects, based on the teaching and guidance presented herein. It is to be understood that the phraseology or terminology herein is for the purpose of description and not of limitation, such that the terminology or phraseology of the present specification is to be interpreted by the skilled artisan in light of the teachings and guidance.

[0262] The breadth and scope of the present invention should not be limited by any of the above-described exemplary aspects, but should be defined only in accordance with the following claims and their equivalents.

SEQUENCE TABLE 1: Polynucleotide Sequences: FIX-Fc

A. B-Domain Deleted FVIII Fc

A(i). B-Domain Deleted FVIII Fc Chain DNA Sequence (FVIII signal peptide underlined, Fc region in bold) (SEQ ID NO:1, which encodes SEQ ID NO:2)

atgcaaaatagagctctocacctgcttctttctgtgccttttgcattctgcttttagtgccaccagaagatactacctg
gggagcagtggaactgtcatgggactatatgcaaagtgatctcggtgagctgctgtggacgcaagatttccctcctaga
gtgccaaaatcttttccattcaacacctcagtcgtgtacaaaaagactctgttttagaattcacggatcaccttttc
aacatcgctaagccaaggccacctggatgggtctgctaggctctaccatccaggctgaggtttatgatacagtggtc
attacacttaagaacatggcttcccatcctgtcagtcctcatgctgttggtgtatcctactggaagcttctgagggga
gctgaatatgatgatcagaccagtcagaggggagaagaagatgataaagtcttccctggggaagccatacatatgtc
tggcaggctcctgaaagagaatgggtccaatggcctctgacccactgtgccttacctactcatatctttctcatgtggac
ctggtaaaagacttgaattcaggcctcatggagccctactagtatgtagagaaggagctctggccaaggaaaagaca
cagaccttgcacaaaattatactacttttggctgtatttgatgaagggaaggtggcactcagaaaacaaagaactcc
ttgatgcaggatagggatgctgcatctgctcgggctggcctaaaatgcacacagtcagtgggttatgtaaacaggctc
ctgcccaggctgattggatgccacaggaaatcagtcctattggcatgtgattggaatgggaccactcctgaagtgcac
tcaatattcctcgaaggctcacacatttcttgtgaggaacctcgccaggcgtccttggaaatctcgcaataactttc
cttactgctcaaacactcttgatggaccttggacagtttctactgttttgtcatabctcttcccaccaacatgatggc
atggaagcttatgtcaaagttagacagctgtccagaggaacccccactcgaatgaaaaataatgaagaagcggaaagac
tatgatgatgatcttactgattctgaaatggatgtggctcaggtttgatgatgacaactccttcccttcccttccaaatt
cgctcagttgccaagaagcatcctaaaacttgggtacattacattgctgctgaagaggaggactgggactatgctccc
ttagtcctcgccccgatgacagaagttataaaagtcaatatttgaacaatggccctcagcggattggttaggaagtac
aaaaaagtcggatttatggcatacacagatgaaacctttaagactcgtgaagctattcagcatgaatcaggaatcttg
ggaccttactttatggggaagttggagacacactgttgattatatttaagaatcaagcaagcagaccatataacatc
tacctcagcgaatcactgatgtccgtccttctgattcaaggagattaccaaagggtgtaaaacatttgaaggatttt
ccaattctgcccaggagaaatattcaaatataaatggacagtgactgtagaagatgggccaactaaatcagatcctcgg
tgctgacctgctattactctagtttctgtaaatatggagagagatctagcttcaggactcattggccctctcctcatc
tgctacaaagaatctgtagatcaaagaggaaaccagataatgtcagacaagaggaatgtcatcctgttttctgtattt
gatgagaaccgaagctggtacctcacagagaatatacaacgcttttcccccaatccagctggagtgacagcttgaggat
ccagagttccaagcctccaacatcatgcacagcatcaatggctatgtttttgatagtttgagttgtcagtttgtttg
catgaggtggcatactggtacattctaagcattggagcacagactgacttcccttctgtcttcttctctggatatacc
ttcaaacacaaaatgggtctatgaagacacactcaccctattcccattctcaggagaaaactgtcttcatgtcgatggaa
aaccaggcttatggattctggggtgccacaactcagactttcggaacagaggcatgaccgcttactgaaggtttct
agttgtgacaagaacactgggtgattattacgaggacagttatgaagatatttcagcatacttgtcagtaaaaaaat
gccattgaaccaagaagcttctctcaaaaccaccagctctgaaacgcatcaacgggaaataactcgtactactctt
cagtcagatcaagaggaaattgactatgatgatcaccatcagttgaaatgaagaaggaagatttgacatttatgat
gaggatgaaaaatcagagccccccagctttcaaaagaaaacacagcactattttattgctgagtgagagggctctgg
gattatgggatgagtagctccccacatgttctcaagaacacagggctcagagtgagcagtgctcctcagttcaagaagtt
gtttccaggaatttactgatggctccttactcagcccttataccgtggagaactaaatgaacatttgggactcctg
gggcatatataagagcagaagttgaagataatcatggtaactttcagaaatcaggcctctcgtccctattccttc
tattctagccttatttcttatgaggaagatcagaggcaaggagcagaacctagaaaaaactttgtcaagcctaatagaa
acaaaaacttacttttggaaagtgcacatcatatggcaccactaaagatgagtttgactgcaaagcctgggcttat
ttctctgatgttgacctggaaaaagatgtgcactcaggcctgattggacccttctggctgcccactaacacactg
aacctgctcatgggagacaagtgacagtaacaggaatttgctctgtttttaccatctttgatgagacaaaagctgg
tacttactgaaaatattgaaagaaactgcagggctcctgcaatccagatggaagatcccacttttaagagaat
tatcgcttccatgcaatcaatggctacataatggatacactacctggcttagtaatggctcaggatcaaaggattcga
tggtatctgctcagcatgggagcaatgaaaacatccattctattcatttcagtgagcatgtgttactgtacgaaaa
aaagaggagtataaaatggcactgtacaatctctatccagggtgtttttgagacagtggaatgttaccatccaaagct
ggaatttggcgggtggaatgccttattggcgagcatctacatgctgggatgagcacactttttctgggtgtacagcaat
aagtgctcagactccccgggaatggcttctggacacattagagattttcagattacagcttcaggacaatattggacag
tgggccccaaagctggccagacttcatattccggatcaatcaatgcctggagcaccaaggagcccttttctggatc
aaggtggatctgttggcaccatgattattcacggcatcaagaccagggtgcccgtcagaagttctccagcctctac
atctctcagtttatcatcatgtatagcttgatgggaagaagtgccagacttatcgaggaattccactggaacctta
atggctcttcttggcaatgtggattcatctgggataaaacacaatatttttaacctccaattattgctcgatcacatc
cgtttgcaccaactcattatagcattcgcagcactcttcgatggagttgatgggctgtgatttaaatagttgcagc

atgccattgggaatggagagtaaagcaatatcagatgcacagattactgcttcatcctactttaccaatatgtttgcc
acctggctccttcaaaagctcgacttcacctccaagggaggagtaatgcctggagacctcaggtgaataatccaaaa
gagtggtgcaagtggacttcagaagacaatgaaagtccagggagtaactactcagggagtaaaatctctgcttacc
agcatgtatgtgaaggagtctctcatctccagcagtcagatggccatcagtggaactctctttttcagaatggcaaa
gtaaaggtttttcagggaaatcaagactccttcacacctggtggaactctctagaccaccggttactgactcgctac
cttcgaattcacccccagagttgggtgcaccagattgccttgaggatggaggttctgggctgagggcacaggacctc
tacgacaaaactcacacatgccaccggtgccagctccagaactcctggggggaacgctcagttctctctccccc
aaacccaaggacacctcatgatctcccggaccttgaggtcacatgctggtggtggagctgagccaagaacct
gaggtcaagttcaactggtacgtggacggcgtggaggtgcataatgccaaagacaaagccgaggaggagcagtaaac
agcagctaccgtggtggtcagcgtcctcacctcctgcaaccaggactggtgaaatggcaaggagtacaagtgaaggtc
tccaacaaagcctcccagccccatcgagaaaaccaatccaaagccaaagggcagccccgagaaccacaggtgtac
acctgcccccatcccgggatgagctgaccaagaaccaggtcagcctgacctgctggtcaaaggcttctatcccagc
gacatcgccgtggagtgaggagcaatgggcagccggagaacaactacaagaccacgcctcccggtgtggactccgac
ggctccttctctctacagcaagctcacctgggacaagagcaggtggcagcaggggaaagctctctcatgctccgtg
atgcatgaggctctgcacaaccactacacgcagaagagcctctccctgtctccgggtaaa

A(ii). Fc DNA sequence (mouse Igk signal peptide underlined) (SEQ ID NO:3, which encodes SEQ ID NO:4)

atggagacagacacactcctctctatgggtactctgctctgggttccaacttccactgggtgacaaaactcacacatgc
ccaccgtgccagcactgaactcctgggaggaccgtcagttctctctccccccaaaacccaaggacacctcatg
atctcccggaccctgaggtcacatgctggtggtggacgtgagccacgaagacctgaggtcaagttcaactggtac
gtggacggcgtggaggtgcataatgccaaagacaaagccgaggaggagcagtaaacagcagctaccgtggtgagc
gtcctcaccgtcctgcaccaggactggctgaaatggcaaggagtacaagtgaaggctctccaacaaagcctcccagcc
cccatcgagaaaaccatctccaaagccaaagggcagccccgagaaccacaggtgtacacctgcccccatcccggat
gagctgaccaagaaccaggtcagcctgacctgctggtcaaaggcttctatcccagcgacatcgccgtggagtgagg
agcaatgggcagccggagaacaactacaagaccacgcctcccggtgtggactccgacggctcctctctctacagc
aagctcaccgtggacaagagcaggtggcagcaggggaaagctctctcatgctccgtgatgcatgaggctctgcacaac
cactacacgcagaagagcctctccctgtctccgggtaaa

B. Full Length FVIII_{FC}

B(i). Full Length FVIII_{FC} DNA Sequence (FVIII signal peptide underlined, Fc region in bold)
(SEQ ID NO:5, which encodes SEQ ID NO:6)

atgcaaatagagctctccacctgcttctttctgtgctttttgcaattctcttttagtggcaccagaagatactacctg
ggtgcagtggaactgtcatgggactatatgcaaagtgatctcggtgagctgctgtggacgcaagatttctctctaga
gtgcaaaaatcttttccattcaacacctcagtcgtgtacaaaaagactctggttgtagaattcacggatcacctttc
aacatcgctaagccaaggccacctggatgggtctgctaggctctaccatccaggctgaggtttatgatcacgtggtc
attacacttaagaacatggcttcccatcctgtcagttctcatgctgttgggtgatcctactggaaagctctgagggga
gctgaatatgatgatcagaccagtcacaaagggagaaagaagatgataaagtcttccctgggtggaagccatataatgct
tggcaggtcctgaaagagaatgggtccaatggcctctgaccactgtgcttacctactcatatctttctcatgtggac
ctggtaaaagacttgaattcaggcctcattggagccctactagtatgtagagaagggagtctggccaaggaaaagaca
cagaccttgacaaaatttatactactttttgctgtatttgatgaagggaaaagtggcactcagaaacaaagaactcc
ttgatgcaggatagggatgctgcatctgctcgggctggcctaaaatgcacacagtcattggttatgtaaacaggtct
ctgccaggtctgattggatgccacaggaaatcagttctattggcatgtgatggaaatgggaccactcctgaagtgcac
tcaatattcctcgaaggctcacacatttcttgtgaggaacctcgccaggcgtccttggaaatctcgccaataactttc
cttactgctcaaacactcttgatggaccttggacagtttctactggtttgtcatatctcttcccaccaacatgatggc
atggaagcttatgtcaaagtacagcgtgtccagaggaaccccaactcgaatgaaaaataatgaagaagcgggaagac
tatgatgatgatcttactgattctgaaatggatgtggctcaggtttgatgatgacaactctccttcttataccaaatt
cgctcagttgccaagaagcatcctaaaacttgggtacattacattgctgctgaagaggaggactgggactatgctccc
ttagtcctcgccccgatgacagaagttataaaagtcaatatttgaacaatggcctcagcggattggttaggaagtac
aaaaaagtccgatttatggcatacacagatgaaacctttaaagactcgtgaagctattcagcatgaatcaggaatcttg
ggacctttactttatggggaagttggagacacactgttgattatatttaagaatcaagcaagcagaccatataacatc
taccctcacggaatcactgatgtccgtcctttgtattcaaggagattaccaaaaggtgtaaaacatttgaaggatttt
ccaattctgccaggagaaatattcaaatataaatggacagtgactgtagaagatgggccaactaaatcagatcctcgg
tgctgaccgcctattactctagtttctgtaatatggagagagatctagcttcaggactcattggccctctcctcatc

tgcatacaaaagaatctgtgagatcaaaagagggaaaaccagataatgtcagacaagagggaatgtcactcctgtttttctgtatctt
gatgagaaccgaagctggtaacctcacagagaatatatacaacgcctttctcccccaatccagctggagtgccagcttgaggat
ccagagttccatgtgttgcaagagggtggcaatactgggtacattctaaagcattgggagcacagactgacttccctttctgtc
ttcttctctctggatataacctcaaaacacaaaaatgggtctatgaagacacacactcaccctattcccatctocaggagagaaac
gtcttcatgtcogatggaaaaaccaggtctatggattctctgggggtggccacaactccagactttcggaacagaggccatgacc
gocctactgaagggtttctagttgtgacaagaacactgggtgatattacagaggacagttatgaagatatttcagcctac
ttgctgagtaaaaaacaatggccattgaacccagaagttctccagaaattcaagacacccctagcactaggccaaaaagcaaa
tttaattgccaccacaaattccagaaaaatgacatagagaagactgacccttgggtttgcaacacagaaacacccctatgocataaa
atataaaaatgtctcctctagtgatttggttgaggtctcttgogacagagttcctactccacatgggctatctctatctgat
ctccagaagccaaaatagagaactttttctgatgatccatccctgggagcaatagacagtaataaagagcttgtctgaa
atgacacacttcaggccacagctccatccacagtggggacatgggtattaccctggagtccaggccctcaattaaagatta
aatggagaaactggggacaactggcagcaacagaggttgaagaaaacttgatttcaaaagtctctagttacatcaaaatctgt
atctcaacaattccatccagacaatttggcagcagggtactgataatacaagttctcttaggaccccccaagttatggccagt
cattatgatagtcatttagatccactctatttggcaaaaaagtcactcccttactgagttcgggtggacctctgagc
ttgagtgaaagaaaataatgattcaaaagttgttagaatcaggtttaaataagacagaaagttccatgggggaaaaaaat
gtatcgtcaacagagagtggttaggttatttaaaagggaaaagaggtctatggacctgctttgttggactaaagataatgoc
ttattcaaaagttagcactctcttggtaaaagacaaaacaccccaataatccagcaactaatagaagagactccact
gatggcccatcatttatttaattgagaatagtcactcagttcggcaaaaatataattagaagtgacactgagtttaaaaaa
gtgacacctttgattcactgacagaatgcttatggcaaaaaatgctacagctttgaggttaaatcatatgtcaaataaa
actacttcatcaaaaacatggaaatgggtccaaacagaaaaaagagggtcccatccacccagatggcacaataccagat
atgctcgttctttaagatgctatctctggccagaatccagcaaggtgggatacaaaaggactcattggaaagaaactctctgaa
ctctggggcaaggcccccagtcacaagcaattagttatcttaggacccagaaaaatctgtgggaaggtcagaatttctctgtc
gagaaaaacaaagttggtagtaggaaaggggtgaatttadaaaggagtaggactcaaaagagatgggtttttccaaagcagc
agaaaacctatttcttactaacttggataatttccatgaaaataatacacacacaaatcaagaaaaaaaattccaggaagaa
atagaaaaagaaggaacacattaatccagagaaatgttagttttgocccagatcacatacagtgactggcactaagaatttc
atgaagaacorttttcttactgagcactaggccaaaatgtagaaggtccatattgacggggatattgctccagtaactcaaa
gatttttaggtcattaaatgattcaacaaatagaacaaaagaaacacacagctcatttcccaaaaaaaggggaggaa
aacttgggaaggttgggaaatcaaaccaagcaaatgttagagaaatattgcatgcaacccaaaggtatctcctaataca
agccagcagaattttgtccagcaacgttagtaagagagctttgaaacaattcagaactccactagaagaaaacagaaactt
gaaaaaaggataatttggggatgacaccccaacccagttgggtccaaaaacatgaaacatttgaccccagagcaccctcaca
cagatagactacaatgagaaggagaaaaggggtcatttactcagttcctccttatccagattgcccctacagaggaggtcattgc
atccctcaagcaaaatagatctccattacccattgcaaaaggtatcattcattccatctatttagaactatatactgacc
agggctcctattccaaagacaacotcttctcacttccagcagcactcttatagaagaaagattctgggggtccaaagaaagc
agtcatttcttacaaggagccaaaaaaaataacctttcttttagccattctaaacttggagagtagctgggtgatcaaga
gaggttggctccctgggggacaagttgccacaaatcagttcaatamaagaaagttgagaaacactgttctccggaaacaa
gacttgcacaaaaacatctggcaaaagttgaattgcttccaaaagttccacatttatccagaaggaactatccctaacggaa
actagcaaatgggtctccctggccactcgggactctctgtggaaagggagcctctctcagggaaacagaggggagcattaaagttgg
aatgaagcaaacagacactggaaaaagttccctttctgtgagagtagcaacagaaaagctctgcaaaagactccctccaaggtta
ttggatccctcttcttgggataaaccactatgggtactcagataccaaaagaaagagttggaaatcccaagagaaagtcacca
gaaaaaacagcttttaagaaaaaggataccattttgtccctgaaacgttgtgaaagcaatcattgcaatagcagcaata
aatgaggggacaaaaataagcccgaaatagaagttcacttggggcaaaagcaaggttaggactgaaaggtctgtctctcaaaac
ccaccagctcttgaaacgccatcaaccgggaaataactcgtactactcttcagtcagatccagagggaaattgactatgat
gataccatattcagttgaaatgaagaaggaagattttgacatttatgatgaggatgaaaaatcagagccccccagagcttt
caaaagaaaaacacagacactattttattgctgcagttggagagggctctgggattatgggatgagtagctccccacatgct
ctaagaaaacaggggtccagagttggcaggtgtccctcagttccaaagaaagttgtttccaggaatttactgatgggtcccttt
actcagcccttataccgtgggagaaactaaatgaacatttgggactccctggggccatataataagagcagaagttgaagat
aatatcatgtgtaactttcagaaaatcagggcctctcgtccctattccctctattctagocctattttcttatgaggaagat
cagagggcaaggagcagaacctagaaaaaacctttgtccagcctaatgaaacccaaaacttacttttggaaagtgcacat
catatggcaccactaaagatgagtttgaotgcaaaagcctgggcttatttctctgatgttgacctggaaaaaagatgtg
cactcaggccctgattggaccccttctgggtctgcccacactaaacacactgaaacccctgctcatgggagacaagtgcacagta
caggaatttgcctctgtttttccaccactcttgatgagacccaaaagctgggtacttccctgaaaaatattggaaagaaaactgc
agggctccctgcaatataccagatggaagatcccacttttaaaagagaaatatanogcttccatgcaatcaatgggtacaba
atggatacactacactggcttagtaattggctcaggtcaaaaggaattcogattcogctcagcctgagatgggcaagaaatgaa
aacatccattctactcatttccagttggacatggttccactgtacgaaaaaaaagaggagtataaaatggcactgtcaaat
ctctatccaggtgtttttgagacagtggaatgttaccatccaaaagctggaaatttggccgggtggaaatgocctatttggc
gagcatctacatgctgggatgagcaccctttttctgggtgtacagaaataaagttgtcagaactccctgggaaatggctctc
ggacacattagagattttccagattacagcttcaggcaaatatggacagttgggccccaaaagctggccagacttcattat
tccggatcaatcaatgocctggagcaccaaaggagccctttttctggatcaaggtggatctgttggcaccacaaatgattatt
cacggcatcaagaccaggggtgcccgccagaagttctccagocctctacatctctcagtttatccatcatgtatagcttt

gatgggaagaagtggcagacttatcgaggaaattccactggaaccttaatggctcttctttggcaatgtggattcatct
 gggataaaaacacaatatTTTTAACCTCCAATTATTGCTCGATACATCCGTTTGACCCAACTCATTATAGCATTTCGC
 agcactcttcgcattggagttgatgggctgtgatttaaatagttgcagcatgccattgggaatggagagtaaaagcaata
 tcagatgcacagattactgcttcatcctactttaccaatatgtttgccacctggtctccttcaaaagctcagacttcac
 ctccaagggaggagtaatgcctggagacctcaggtgaataatccaaaagagtggctgcaagtggacttccagaagaca
 atgaaagtacaggagtaactactcagggagtaaaatctctgcttaccagcatgtatgtgaaggagtctcctcatctcc
 agcagtcaagatggccatcagtggaactctcttttttcagaatggcaagtaaaaggtttttcagggaaaatcaagactcc
 ttcacacctgtggtgaactctctagaccaccgttactgactcgctaccttgaattcacccccagagtgggtgac
 cagattgcctgaggatggagggttctgggctgagggcacaggacctctacgacaaaactcacacatgccaccctgac
 ccagctccagaactcctggggcggaccgtcagttctctcttcccccaaaacccaaggacacctcatgactctcccg
 acccctgaggtcacaatgctggtggtggaactgagccaagaacctgaggtcaagtccaactggtacgtggagcggc
 gtggaggtgcataatgccaagacaaagccgaggaggagcagtaaacagcagctaccgtgtggtcagcgtcctcacc
 gtctgcaccaggactggctgaatggcaaggagtacaagtgcaaggctctcaacaaagccctcccagccccatcgag
 aaaacctctccaaagccaaagggcagccccgagaaccacaggtgtacacctgccccatcccgggatgagctgacc
 aagaaccaggtcagcctgacctgctggtcaaaggcttctatcccagcgacatcgccgtggagtgggagagcaatggg
 cagccggagaacaactacaagaccacgctcccggtgtggactccgacggctccttcttctctacagcaagctcacc
 gtggacaagagcaggtggcagcaggggaaactcttctcatgctccgtgatgcatgaggctctgcacaaccactacacg
 cagaagagcctctcctgtctccgggtaaa

C(i). Heavy Chain (HC)-Fc DNA sequence (no linker between HC and Fc) (signal peptide underlined, Fc region in bold) (SEQ ID NO:7, which encodes SEQ ID NO:8)

atgcaaatagagctctccacctcttctttctctgctttttgcaattctctttatgtccaccagaagatactacctg
 ggtgcagtggaactgtcatgggactatatgcaaagtgatctcggtgagctgctgtggagcgaagatttctctctaga
 gtgccaaaatcttttccattccaacacctcagctcgtgtacaaaaagactctggtttgtagaattcaaggatcacctttc
 aacatcgcctaagccaaggccaacctggatgggtctgctaggtcctaccatccaggctgaggtttatgatacagtggtc
 attacacttaagaacatggcttccatcctgtcagctcttcatgctgttgggtgatacctactggaaaactctctgagggg
 gctgaaatgatgatacagaccagtcacaaggagaaagaagatgataaagtcttccctgggtggaagccaatacataatg
 tggcaggtcctgaaagagaaatgggtccaatggcctctgacccaactgtgccttaactactcatactttctcatgtggac
 ctggtaaaagacttgaaatcaggcctcattggagcctactagtagtagagagggagctctggccaaggaaaagacac
 agaccttgcacaaaattataactactttttgctgtatttgatgaaagggaaaagtggcactcagaaacaaagaactcct
 tgatgcaggatagggatgctcagctcgtcgggctggcctaaaatgcaacacagtcfaatgggttatgtaaacaggtctc
 tggcaggtctgatggatgccaacaggaatcagctctattggcatgtgattggaaatgggcaacctcctgaaagtgcact
 caatatcctcgaagggtcacacatttctgtgaggaacctatgcccaggcgtccttggaaaatctcgcctaactttcc
 ttactgctcaaacactcttgatggacctggacagtttctactgttttgtcatactcttcccaccaacatgatggca
 tggaaagcttatgtcaaagtagacagctgtccagaggaacccccactacgaatgaaaaataatgaagaagcggaaagact
 atgatgatgatcttaactgattctgaaatggatgtggtcaggtttgatgatgacaactctccttcttataccaaaatc
 gctcagttgccaagaagcatcctaaaacttgggtacattacattgctgctgaagaggaggactgggactatgctcctc
 tagtctcgtcccccgatgacagaagttataaaaagtcaataattgaaacatggcctcagcggattggttaggaagtaca
 aaaaagtccgatttatggcatacacagatgaaacctttaagactcgtgaagctatcagcatgaaatcaggaaatcttgg
 gacctttactttatggggaagttggagacacactggtgattatattaaagaaatcaagcaagcagaccataatacatct
 accctcacggaatcactgatgtccgtcctttgtattcaaggagattaccaaaaaggtgtaaaaacattgaaaggattttc
 caattctgcccaggagaaataatcaaaataaaaatggacagtgactgtagaagatggggccaactaaaatcagatcctcgg
 gctgacccgctattactctagtttctgtaataatggagagagatctagcttcaggactcattggcctctcctcatct
 gctacaaagaaatctgtagatcaaagaggaaaccagataaatgtcagacaagaggaaatgtcatcctgttttctgtattt
 atgagaacogaagctggtaacctcacagagaatatacaacgctttctcccaatccagctggagtgacgcttgaggatc
 cagagttccaagcctccaacatcatgcacagcatcaatggctatgtttttgtagtggcagttgtcagtttggtttgc
 atgaggtggcatactgggtacattctaagcattggagcagagactgacttcttctctctctctgataatcct
 tcaaacacaaaatgggtctatgaaagacacactcaccctattcccattctcaggagaaactgtcttcatgtcagatggaaa
 acccaggtctatggattctggggtgccaacactcagactttcggaaacagagggcatgaccgcttactgaaagttctta
 gttgtgacaagaacactgggtgattattacagaggacagttatgaaagatattcagcataacttgctgagtaaaaaacaatg
 ccattgaaaccaagagacaaaactcacacatgcccaccgtgcccagctccagaactcctggggcggaccgtcagctctcc
 tcttcccccaaaaacccaaggacacctcatgatctcccgaccctgaggtcacatgctggtggtggagctgagcc
 acgaagacctgaggtcaagttcaactggtaactgagcggcgtggaggtgcataatgccaagacaaagccgaggagg
 agcagtaacaacagcagctaccgtgtggtcagcgtcctcaccgtcctgcaccaggactggctgaaatggcaaggagtaca
 agtgaaggtctccaaacaaagccctcccagccccatcgagaaaaacatctccaaagccaaagggcagccccgagaac
 cacaggtgtacacctgccccatcccgggatgagctgaccaagaaccaggtcagcctgacctgctggtcaaaggct
 tctatcccagcgacatcgccgtggagtgaggagcaatgggcagccggagaaacactacaagaccacgctcctccgtgt

tggactcogacgggtccttcttctctacagcaagctcaccgtggacaagagcaggtggcagcaggggaacgtcttct
catgctcogtgcagtgatgaggtctgcacaaccactacacgcagaagagcctctccctgtctccgggtaaa

C(ii). Heavy Chain (HC)-Fc DNA sequence (5 amino acid linker between HC and Fc) (signal peptide underlined, Fc region in bold, 5 amino acid linker is double-underlined) (SEQ ID NO:9, which encodes SEQ ID NO:10)

atgcaaaatagaagctctocacctgcttctttctgtgccttttgcgattctgctttaatgccaccagaagatactactcctg
gggtgcagtggaactgtcatgggactatatgcaaagtgatctcggtgagctgcctgtggacgcaagatttctctctaga
gtgccaaaatotttttccattcaacacctcagtcgtgtacaaaaagactctgtttgtagaattcaaggatcaccttttc
aacatcgcctaagccaaggccaccctggatgggtctgctaggtcctaccatccaggctgaggttta tgatacagtggtc
attacacttaagaacaatggcttcccatcctgtcagtccttcatgctgtttggtgta tctacttgaaagcttctgagggg
gctgaatatgatgatacagaccagtcaaagggagaaagaagatgataaagtcttccctggtggaagccatacatatgct
tggcaggtcctgaaagagaaatgggtccaatggcctctgaccactgtgccttaccactcatacttctctcatgtggac
ctggtaaaagacttgaattcaggcctcattggagccctactagtatgtagagaagggagctctggccaaggaaaagaca
cagaccttgccacaaaatttatactacttttggctgtatttgatgaagggaaaagtggcactcagaaaacaaagaactcc
ttgatgcaggatagggatgctgcactctgctcgggctggcctaaaaatgcaacagtcattgggtatgtaaacaggctct
ctgccaggctctgattggatgccacaggaaaatcagtcctattggcatgtgattggaaatgggcaccactcctgaagtgcac
tcaatatctctogaaggtcacaatttctgtgaggaaccaatgccaggcgtccttggaaaatctcgccaaataactttc
cttactgctcaaaacactcttgatggaccttggacagtttctactgttttgtcatactcttcccaccaacatgatggc
atggaagcttatgtcaaagtagacagctgtccagaggaaccccaactacgaatgaaaaataatgaagaagcggagac
tatgatgatgattctactgattctgaaatggatgggtcaggtttgatgatgacaactctccttcttataccaaatt
cgctcagttgccaagaagcatcctaaaacttgggtacattgctgctgtaagaggaggactgggactatgctccc
ttagtcctcgccccogatgacagaagttataaaagtcaatatttgaacaatggcctcagcggattggtaggaagtac
aaaaaagtccgatttatggcatacacagatgaaacctttaagactcgtgaagctattcagcatgaaatcaggaaatcttg
ggaccttaactttatgggggaagttggagacacactgttgattataatttaagaatcaagcaagcagaccataaacatc
tacctcaaggaaatcactgatgtcogtcttggatttcaaggagattaccaaaaaggtgtaaaaaatttgaaggatttt
ccaattctgcccaggagaaaatattcaaatataaatggacagtgactgtagaagatgggccaactaaaacagatcctcgg
tgctgaccogctattactctagtttctgtaaatatggagagagatctagcttcaggactcattggcctctcctcact
tgctacaaagaatctgtagatcaaagaggaaaccagataatgtcagacaagaggaaatgtcactcctgttttctgtattt
gatgagaaccgaagctggtacctcagagagaatatacaacgctttctcccaatccagctggagtgacgcttgaggat
ccagagttccaagcctccaacatcatgcacagcatcaatggctatgtttttgatagtttgagttgtcagtttgtttg
catgaggtggcatactggtacattotaagcattggagcacagactgacttcttctgtcttctctctctggataacc
ttcaaacacaaaaatggtctatgaagacacactcaccctattcccattctcaggagaaaactgtcttcatgtcogatgaa
aaccaggctctatggattctgggtgcccacaactcagacttctggaaacagaggcatgaccgccttactgaaggtttct
agttgtgacaagaacaactggtgattatcagaggacagttatgaagataatttcagcatacttctgtgagtaaaaaaat
gccattgaaaccaagaagcttctccagaatgcaaaaactcacacatgccaccogtgcccagctccagaactcctgggc
ggaccgtcagttctctcttcccccaaaaaccaaaggacaccctcatgatctcccgaccctgaggtcacaatgcgtg
gtggtggacgtgagccagcagaagaccctgaggtcaactgggtcagtgagcggcgtggaggtgcaataatgccaag
acaaagccgctgggagcagtcacaacagcagtcacogtgggtcagcgtcctcaccgtcctgcaccaggactggctg
aatggcaaggagtacaagtgcaaggtctccaaacaaagccctccagccccatcgagaaaaaccatctccaaagccaaa
gggcagccccgagaaccacaggtgtacaccctgccccatccccgggatgagctgaccaagaaccaggtcagcctgacc
tgctgtgcaaggcttctatacccagcgacatcgccgtggagtgaggagcaatgggcagccggagaaacactacaag
accacgctcccggtgttggactccgacggctccttctctctacagcaagctcaccgtggacaagagcaggtggcag
caggggaaogtcttctcatgctcogtgcagtgaggtctgcacaaccactacacgcagaagagcctctccctgtct
ccgggtaaa

C(iii). Light Chain (LC)-Fc DNA sequence (signal peptide underlined, Fc region in bold) (SEQ ID NO:11, which encodes SEQ ID NO:12)

atggagacagacacactcctctgatatgggtactgctgctctggttccaggttccactggtgaaaataactogtactact
cttcagtcagatcaagaggaaaattgactatgatgataccataatcagttgnaatgaagaaggaagattttgacatttat
gatgaggtatgaaaaatcagagacccccagcgtttcaaaaagaaaaacagacactattttattgtctgagtgagagggctc
tgggattatgggatgagtagctccccacatggttotaagaaaacagggctcagagtggtcagtgctcctcagttcaagaaa
gttgttttccaggaatttactgatggctccttactcagcccttataccgtggagaaactaaaatgaacatttgggactc
ctggggccataatataagagcagaagttgaagataatataatggtaacttttcagaaaatcaggcctctcgtccctattcc
ttctattctagccttatttcttatgaggaagatcagaggtcaaggagcagaacctagaaaaaactttgncaaagcctaat

gaaacccaaaacttacttttggaaagtgcaacatcataatggcaccocactaaagatgagtttgactgcaaagcctgggct
tatttctctgatgttgacctggaaaaagatgtgcactcaggcoctgattggaccocctctcgtctcgcacactaacaca
ctgaacctgctcatgggagacaagtgcagctacaggaatttgctctgtttttcaccatctttgatgagacccaaaagc
tggtacttcaactgaaaaatggaagaaaactgcagggtccctgcaataccagatggaagatcccacttttaaagag
aattatcgcttccatgcaatcaatggctacataatggatatacactaocctggcttagtaatggctcaggatcaaaggatt
cgatggatctgctcagcatgggcagcaatgaaaacatccattctattcatttcagtggacatgtgttcaactgtacga
aaaaagaggagtaaaaaatggcactgtacaatctctataccaggtgtttttgagacagtggaaaatgttaccatccaaa
gctggaatttggcgggtggaatgccttattggogagocatacactgctgggatgagcacactttttctggtgtacagc
aataagtgtcagactcccctgggaatggcttotggacacattagagattttcagattacagcttcaggacaataatgga
cagtgggccccaaagctggccagacttcattattccggatcaatcaatgcoctggagcacaaggagccctttcttgg
atcaaggtggatctgttggcaccatgattattcagggcatcaagaccagggtgcccgtcagaagttctccagcctc
tacatctctcagtttatcatcatgtatagctcttgatgggaagaagtggcagacttatogaggaaatccactggaacc
ttaatggctcttcttggcaatgtggattcatctgggataaaaacacaataattttaaccctccaattattgctogatac
atccgtttgcacccaactcattatagcattcgcagcactcttcgcattggagttgatgggctgtgatttaaaatagttgc
agcatgccattgggaatggagagtaaagcaataccagatgcacagattactgcttcatcctactttaccaataatggtt
gccacctggtctccttcaaaagctcgacttcacctccaaggaggagtaatgcoctggagacctcagggtgaataatcca
aaagagtggctgcaagtggacttcagaagacaatgaaagtcaacaggagtaactactcaggaggtaaaaatctctgctt
accagcatgtaatgtgaaggagttcctcatctccagcagtcagaatggccatcagtggaactctcttttttcagaatggc
aaagtaaaggtttttcagggaatcaagactccttcacacctgtgggtgaactctctagaccaccogttactgactcgc
taccttcgaattcacccccagagttgggtgcaccagattgcccctgaggatggagggtctctgggctgcgagggcagggac
ctctacgacaaaactcacacatgcccacctgcccagctccagaactcctgggoggaaccgtcagttctctcttcccc
ccaaaaccaagcacccctcatgatctccgggacccctgagggtcacaatggctgggtgggtggacgtgagccacgaagac
cctgaggtaagttcaactggtagctggagcggctggaggtgcaataatgccaagacaaagccgcccggaggagcagtac
aacagcacgtaccgtgtggctcagcgtcctcaccgtcctgcaccaggactggctgaaatggcaaggagtacaagtgaag
gtctccaacaaagccctcccagccccatogagaaaaacatctccaaagccaaagggcagccccgagaaccaaggtg
tacacctgcccccatcccgggatgagctgaccaagaaccagggtcagcctgacctgctggtcaaaaggcttctatacc
agcgacatcgccgtggagtgaggagcaatgggcagccggagacaactacaagaccagcctccogtgttggactcc
gacggctccttcttctctacagcaagctcaccgtggacaagagcaggtggcagcaggggaacgtcttctctcatgctcc
gtgatgcatgaggctctgcacaaccactacacgcagaagagcctctccctgtctccgggtaaa

D. FIX-Fc Chain DNA Sequence (SEQ ID NO:13, which encodes SEQ ID NO:14)

pSYN-FIX-030 Nucleotide sequence (nt 1 to 7583):

FIX exon 1 (signal peptide, 1st amino acid propeptide): nt 690-777
FIX mini intron: nt 778-1076
FIX propeptide sequence : nt 1077-1126
Mature FIX sequence : nt 1127-2371
Fc : nt 2372-3052

gcgcgcttgacattgattattgactagttattaatagtaatcaattacggggctcattagttcatagcccatatg
agttccgcgttacataacttacggtaaatggcccgcctggctgaccgcccacgacccccgccattgacgtcaataa
tgacgtatgttcccataagtaacgccaatagggactttccattgacgtcaatgggtggagatattacggtaaacctgcc
acttggcagtagatcaagtgtatcatatgccaagtacgccccctattgacgtcaatgacggtaaatggcccgcctggc
attatgcccagtagatgaccttatgggactttcctacttggcagtagatctacgtattagtcacgtctattaccatgg
tgatgcgggttttggcagtagatcaatggggcgtggatagcgggttgactcacggggatttccaagtctccaaccattg
acgtcaatgggagtttggtttggcaccaaaatcaacgggactttccaaaatgtcgtacaactccgccccattgacgc
aaatggggcgttaggcgtgtacgggtgggaggtctatataagcagagctctctggctaaactagagaaccactgcttact
ggcttatcgaaattaatacagactcactatagggagacccaagcttcgcgacgtacggccgcccaccatgcagcgcgtga
acatgatcatggcagaatcaccaggcctcatcaccatctgccttttaggatattactcagtgctgaatgtacaggtt
tgtttccttttttaaaatacattgagtagcttgcccttttagatatagaaatattctgatgctgtcttcttcaactaat
tttgattacatgatttgacagcaatattgaagagttaacagccagcagcaggttggttaagtactgtgggaacatca
cagattttggctccatgcctaaagagaaaatgggctttcagattatttggattaaaacaaagactttcttaagagat
gtaaaattttcatgatgttttctttttgctaaaactaaagaattattcttttacatttcagttttcttgatcatga
aaacgccaacaaaattctgaatcggccaaagaggtataattcaggtaaatgggaagagttgttcaaggggaatctaga
gagagaatgtatggaagaaaagtgtagtttgaagaagcagagaagttttgaaaacactgaaagaacaactgaatt
ttggaagcagtagttgatggagatcagtgtagtccaatccatgtttaaattggcggcagttgcaaggatgacattaa
ttcctatgaatgttgggtgctcctttggatttgaaggaaagaactgtgaattagatgtaacatgtaacattaagaatgg
cagatgcgaagcagttttgtaaaaatagtgctgataacaagggtggtttggctcctgtactgagggatatcgacttgca

aaaccagaagtcctgtgaaccagcagtgccatttccatgtggaagagtctctgtttcacaacttctaagctcaccog
tgctgagactgttttctctgatgtggactatgtaaattctactgaagctgaaaccatttggataacatcactcaaag
caccatcatttaagtacttccactcgggtgttggaggagaagatgccaaaccaggtcaattcccttggcaggtgt
tttgaatggtaaaagttgatgcattctgtggaggctctatogttaatgaaaaatggattgtaactgctgccactgtgt
tgaaactgggtttaaattacagttgtcgcaggtgaacataatattgaggagacagaacatacagagcaaaagcgaaa
tgtgattcgaattattcctcaccacaactacaatgcagctattaataagtaacaacctgacattgcccttctggaact
ggacgaacccttagtgctaaacagctacgttacacctatttgcatgtgacaaaggaatacacgaacatcttctcaa
atgggatctggctatgtaagtggtggggaagagtctccacaagggagatcagcttagttctcagtaccttag
agttccactgttgaccgagccacatgtctcgcattcacaagttcaccatctataacaacatgttctgtgctggctt
ccatgaaggaggtagagattcatgtcaaggagatagtgggggacccatgttactgaagtggaagggaccagtttctt
aactggaattattagctggggtgaagagtgtgcaatgaaaggcaaatatggaatataaccaaggtgtcccggatgt
caactggattaaggaaaaaacaagctcactgacaaaactcacacatgccaccgtgccagctccggaactcctggg
cggaccgtcagttctctctcccccaaaaacccaaggacacctcatgatctccggacccttgaggtcacatgct
gggtgggtggacgtgagccacgaagacctgaggtcaagttcaactggtacgtggacggcgtggaggtgcataatgcaa
gacaaagccgcgggaggagcagtaaacagcagctaccgtgtggtcagcgtcctcaccgtcctgcaccaggactggct
gaatggcaaggagtacaagtgcaaggtctccaacaaagccctcccagccccatcgagaaaacctctccaaagcaa
agggcagccccgagaaccacaggtgtacaacctgccccatcccgggatgagctgaccaagaaccaggtcagcctgac
ctgctggtcaaaggcttctatcccagcgacatcgccgtggagtgaggagcaatgggcagccggagaacaactaca
gaccagcctcccgtgttgactccgacggctccttcttctctacagcaagctaccgtggacaagagcaggtggca
gcaggggaacgtcttctcatgctccgtgatgcattgaggtctgacacaccactacacgcagaagagcctctccctgtc
tccgggtaaatgagaattcagacatgataagatacattgatgagtctggacaaaccacaactagaatgcagtgaaaa
aatgcttatttggtaatttggatgctattgcttatttggtaacctataagctgcaataaaacaagttgggggtgg
gcgaagaactccagcatgagatccccgcgtggaggatcatccagccggcgtcccggaaaaacgattccgaagcccaac
cttcatagaaggcggcgggtggaatcgaaatctcgtagcagctgtcagctcctgctcctcggccacgaagtgcacgcag
ttgcccggcgggtcgcgcaggcgaactcccgcacctcggcgtacagctcgtccaggccgcgacccacaccagggcagg
gtgtgtcggcaccacctggctcctggaccgcgtgatgaacaggggtcagctcgtcccggaccacaccggcgaagtgc
tctccacgaagtcccgggagaaccggagccggctgggtccagaactcgaccgctccggcgacgtcgcgcgcggtgagc
accggaacggcactgggtcaacttggccatgggttagttctcacttctcgtattatactatgccgatatactatgcc
gatgattaattgtcaacacgtgctgatcagatccgaaaatggatatacaagctcccgggagctttttgcaaaaagccta
ggcctccaaaaaagcctcctcactacttctggaatagctcagagggcagagggcggcctcggcctctgcataaataaaaa
aaattagtcagccatggggcgggagaatggggcggaaactggggcggaggttagggggcgggatggggcggagttaggggcggga
ctatgggtgctgactaattgagatgcatttgcatacttctgctgctggggagcctggggactttccacacctggtcag
ctagcttctgtaggctccgggtgcccgtcagtgggcagagcgcacatcgcccacagctcccggagaagtggggggaggg
gtcggcaattgaaccgggtgcttagagaaggtggcgcggggtaaactgggaaagtgatgctgctgactggctccgctt
ttcccggaggggtgggggagaaccgtatataagtgagtagtcgcccgtgaaacttcttttccgcaacgggtttgccc
agaacacaggttaagtcagtggttctccgcgggctggcctcttacgggttatggccttgcgtgcttgaatt
acttccacttggctccagtcagtgattcttgatcccagctggagccagggcgggcttgcgtttaggagccctt
cgctcgtgcttgagttaggcctggcctggggcgtggggcgcggcgtgcaatctggtggcaccttgcgcctgtc
tcgctgcttccgataagctcttagccatttaaaattttgatgacctgctgcgacgcttttttctggcaagatagtc
ttgtaaatgcccggccaggatctgcacactggatttccggttttggggcgcgggcccggcagggggccgtgctccc
agcgcacatgttccggcagggcggggcctgcgagcgcggccaccgagaatcggacgggggtagtctcaagctggccggc
ctgctctggtgctgctgctcgcgcgcgctgtatcgccccgctggggcggcaaggctggcccggctcggcaccagttg
cgtgagcggaaagatggccgcttcccggcctgctccagggggctcaaaatggaggacgcggcgtcgggagagcggg
cgggtgagtcacccacacaaaggaaaggggcttccgctcctcagcctcgtctttaggttggggggaggggttttatgcga
cgccgtccaggcacctcgattagttctggagcttttggagtagctcgtctttaggttggggggaggggttttatgcga
tggagtttccccacactgagtggtggagactgaagttaggccagcttggcacttgatgtaattctccttggaaattg
ccctttttaggttggatcttgggtcattctcaagcctcagacagtggttcaaagttttttcttccatttcagggtgt
cgtgaacacgtggctcgcggccgcgcggccaccatggagacagacacactcctgctatgggtactgctgctctgggttc
caggttccactgggtgacaaaactcacacatgccaccgtgccagcactgaactcctgggaggaccgtcagctctcc
tctcccccaaaaacccaaggacacctcatgatctcccggaccctgaggtcacatgctggtggtggacgtgagcc
acgaagacctgaggtcaagttcaactggtacgtggacggcgtggaggtgcataatgccaagacaaagccgcgggag
agcagtaaacagcagctaccgtgtggtcagcgtcctcaccgtcctgcaccaggactggctgaatggcaaggagtaca
agtgaaggtctccaacaaagcctcccagccccatcgagaaaacctctccaaagcgaaggcagggcaggaac
cacaggtgtacacctgccccatcccgcgatgagctgaccaagaaccaggtcagcctgacctgctggtcaaaagct
tctatcccagcagatcgccgtggagtggaagcaatggcagccgggagaacaactacaagaccagcctcccgtgt
tggactccgacggctccttctctacagcaagctcaccgtggacaagagcaggtggcagcaggggaaactcttct
catgctccgtgatgcatgaggtctgcacaaccactacacgcagaagagcctctccctgctcctgggtaaatgactcg

agagatctggccggctgggcccgtttcgaaggttaagcctatccctaaccctctcctcgggtctcgattctacgcgtacc
 ggtcatcatcaccatcaccattgagtttaaaccogctgatcagcctcgactgtgccttctagttgccagccatctggt
 gtttggccctccccctgccttcccttgaccctggaaggtgccactcccactgtcctttcctaataaaaatgaggaaatt
 gcatcgattgtctgagtaggtgtcattctattctgggggggtggggggggcaggacagcaagggggaggattgggaa
 gacaatagcaggcatgctggggatgagggtgggtctatggcttctgaggcggaaagaaccagtgggcgtaatacggtt
 atccacagaatcaggggataacgcaggaaagaacatgtgagcaaaaggccagcaaaaggccaggaaccgtaaaaaggc
 cgcgttctggcggtttttccataggctccgccccctgacgagcatcacaataatcgacgctcaagtcagaggtggcg
 aaaccggacaggactataaagataaccaggcgtttccccctagaagctccctcgtgcgctctcctgttccgaccctgcc
 gcttaccggatacctgtccgcctttctcccttcgggaagcgtggcgctttctcatagctcacgctgtaggtatctcag
 ttccgggtgtaggtcgttcgctccaagctgggctgtgtgcacgaaccccccttcagcccagccgctgcgccttatccgg
 taactatcgtcttgagtcacaaccggtaagacacgacttatcgccactggcagcagccactggtaacaggattagcag
 agcagaggtatgtagggcgtgtacagagttcttgaagtggtggcctaactacggctacactagaagaacagtatctgg
 tatctgcgctctgctgaagccagttaccttcggaaaaagagttggtagctcttgatccggcaaaacaaaccacggctgg
 tagcgggtgggttttttggtttgcaagcagcagattacgcgcagaaaaaaggatctcaagaagatcctttgatcttttc
 tacggggctctgacgctcagtggaacgaaaactcacgttaagggattttgggtcatgacattaacctataaaaataggcg
 tatcacgagggcctttcgtctcgcgcggtttcgggtgatgacggtgaaaacctctgacacatgcagctcccgagacggg
 cacagcttctgtgtaagcggatgcccgggagcagacaagcccgtcagggcgcgctcagcgggtgttggcgggtgtcgggg
 ctggcttaactatgcccgcacagagcagattgtactgagagtgaccataatgcccgtgtgaaataccgcacagatgc
 gtaaggagaaaaataccgcacagggcgcattcgcattcaggctgcgcaactgttgggaagggcgatcgggtgcggggcc
 tcttcgctattacgcca

E. Fc DNA sequence (mouse Igκ signal peptide underlined) (SEQ ID NO:3, which encodes SEQ ID NO:4) This is the Fc cassette from pSYN-FIX-030. In addition, there is a separate Fc expression cassette that was transfected into the cell line in plasmid pSYN-Fc-015 that encodes the same amino acid sequence, but contains a few noncoding changes. The second copy of Fc encoding sequence enables a better monomer: dimer ratio.

atggagacagacacactcctcctatgggtactcctcctctgggttccaggttccactcctgacaaaaactcacacatgc
 ccaccgtgcccagcacctgaactcctgggaggaccgtcagcttctcctcttccccccaaaacccaaggacaccctcatg
 atctcccggacccttgaggtcacatgcgtgggtgggtggacgtgagccacgaagaccctgaggtcaagttcaactggtag
 gtggacggcgtggaggtgcataatgccaaagacaaagccgcgggaggagcagtacaacagcacgtaccgtgtggtcagc
 gtccctcaccgtcctgcaccaggactggctgaatggcaaggagtacaagtgcaaggtctccaacaaagccctcccagcc
 cccatcgagaaaaaccatctccaaagccaaagggcagccccgagaaccacaggtgtacaccctgccccatcccgcgat
 gagctgaccaagaaccaggtcagcctgacctgctgggtcaaaggcttctatcccagcagacatcgccgtggagtgggag
 agcaatgggcagccggagaacaactacaagaccacgcctcccgtgtggactccgacggctccttctcctctacagc
 aagctcaccgtggacaagagcaggtggcagcaggggaacgtcttctcatgctcctgatgcatgaggctctgcacaac
 cactacacgcagaagagcctctccctgtctccgggtaaa

Sequence Table 2: Polypeptide Sequences

A. B-Domain Deleted FVIII-Fc Monomer Hybrid (BDD FVIII-Fc monomer dimer): created by coexpressing BDD FVIII-Fc and Fc chains.

Construct = HC-LC-Fc fusion. An Fc expression cassette is cotransfected with BDD FVIII-Fc to generate the BDD FVIII-Fc monomer-. For the BDD FVIII-Fc chain, the Fc sequence is shown in bold; HC sequence is shown in double underline; remaining B domain sequence is shown in italics. Signal peptides are underlined.

A(i). B domain deleted FVIII-Fc chain (19 amino acid signal sequence underlined) (SEQ ID NO:2)

MQIELSTCFFLCCLRFCFSATRRYYLGAVELSWDYMQSDLGELPVDARFPPRVPKSFPNTSVVYKKTLFVEFTDH_F
NIAKPRPPWMGLLGPTIQAEVYDTVVITLKNMASHPVSLHAGVSYWKASEGAEYDDQTSQREKEDDKVFPGGSHTYV
WQVLKENGPMASDPLCLTYSYLSHVDLVKDLNSGLIGALLVCREGSLAKEKTQTLHKFILLFAVFDEGKSWHSETKNS
LMQDRDAASARAWPKMHTVNGYVNRSLPGLIGCHRKSVYWHVIGMGTTPEVHSIFLEGHTFLVRNHRQASLEISPITF
LTAQTLLMDLGQFLLFCHISSHQHDGMEAYVKVDSCPEEPQLRMKNEEAEDYDDDLTDSEMDVVRFDDDNSPSFIQI
RSVAKKHPKTWVHIAAEEEDWYAPLVLAPDDRSYKSQYLNNGPQRIGRKYKKVRFMAYTDETFKTREATQHESGIL
GPLLYGEVGDTLLLIFKNQASRPYNIYPHGITDVRPLYSRRLPKGVKHLKDFPILPGEIFKYKWTVTVEDGPTKSDPR
CLTRYSSFVNMERDLASGLIGPLLICYKESVDQRNQIMSDKRNVILFSVFDENRSWYLTENIQRFLPNPAGVQLED
PEFQASNIMHSINGYVFDSLQLSVCLHEVAYWYILSIGAQTDFLSVFFSGYTFKHKMVYEDTLTLSPFSGETVFMSME
NPGLWILGCHNSDFRNRGMTALLKVSSCDKNTGDYYEDSYEDISAYLLSKNNAIEPRSFSQNPPVLKRHQREITRTTL
QSDQEEIDYDDTISVEMKKEDFDIYDEDENQSPRSFQKKTRHFIAAVERLWDYGMSSSPHVLRNRAQSGSVPQFKKV
VFQEFTDGSFTQPLYRGELNEHLGLLGPYIRAEVEDNIMVTFRNQASRPYSFYSSLISYEEDQRQGAEPRKNFVKPNE
TKTYFWKVQHHMAPTKDEFDCKAWAYFSDVLEKDVHSGLIGPLLVCHTNTLNPAHGRQVTVQEFALFFTIFDETKSW
YFTENMERNCRAPCNIQMEDPTFKENYRFHAINGYIMDTLPGLVMAQDRIRWYLLSMGSNENIHSIHFSGHVFTVRK
KEEYKMALYNLYPGVFETVEMLPSKAGIWRVECLIGEHLHAGMSTLFLVYSNKQTPLGMASGHIRDFQITASGQYGQ
WAPKLARLHYSGSINAWSTKEPFSWIKVDLLAPMIIHGIKTQGARQFSSLYISQFIIMYSLDGKKWQTYRGNSTGTL
MVFFGNVDSSGIKHNIFNPPIIARYIRLHPTHYSIRSTLRMELMGCDLNSCSMPLGMESKAISDAQITASSYFTNMFA
TWSPSKARLHLQGRSNAWRPQVNNPKEWLQVDFQKTMKVTGVTTQGVKSLLTSMYVKEFLISSQDGHQWTLFFQNGK
VKVFQGNQDSFTPVVNSLDPPLLTRYLRIHPQSWVHQIALRMEVLGCEAQDLYDKTHTCPPAPELLGGPSVFLFP
KPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVSVLTVLHQDWLNGKEYKCKV
SNKALPAPIEKTISKAGQPREPQVYTLPPSRDELTKNQSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSD
GSFFLYSKLTVDKSRWQGNVFSCSVMHEALHNHYTQKSLSLSPGK

A(ii). Fc chain (20 amino acid heterologous signal peptide from mouse Igk chain underlined) (SEQ ID NO:4)

METDTLLLWVLLLWPGSTGDKTHTCPPCAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWY
VDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAGQPREPQVYTLPPSRD
ELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTVDKSRWQGNVFSCSVMHEALHN
HYTQKSLSLSPGK

B. Full length FVIII-Fc monomer hybrid (Full length FVIII-Fc monomer dimer): created by coexpressing FVIII-Fc and Fc chains.

Construct = HC-B-LC-Fc fusion. An Fc expression cassette is cotransfected with full length FVIII-Fc to generate the full length FVIII-Fc monomer. For the FVIII-Fc chain, the Fc sequence is shown in bold; HC sequence is shown in double underline; B domain sequence is shown in italics. Signal peptides are underlined.

B(i). Full length FVIIIc chain (FVIII signal peptide underlined) (SEQ ID NO:6)

MQIELSTCFFLCLLRFCFSATTRYYLGAVELSWDYMQSDLGELPVDARFP~~PR~~VPKSFPFNTSVVYKKT~~LF~~VEFTDHLF
 NIAKPRPPWMLLGGPTIQAEVYD~~TVVITLKNMASHPVSLHAVGVSYWKASEGAEYDD~~TSREKEDDKVFP~~GG~~SHTYV
 WQVLKENGPMASDPLCLTYSYLSHV~~DLVKDLNSGLIGALLVCREGSLAKEKT~~THKFL~~LLFAV~~FDEGKSWHSETKNS
 LMQDRDAASARAWP~~MHTVNGYVNRSLPGLIGCH~~RKSVYWHVIGMGTTPEVHSIFLE~~GHTFLVRNHR~~CASLEISPITF
 LTA~~QTL~~LLMDLQ~~FLLFCH~~ISSHQHDGMEAYVKV~~SDSCPEEPQLRMKNNEEAEDYDDD~~LDSEMDVVR~~DDD~~NSPSFIQI
 RSVAKKHPKTWVHYIAAEEDWDYAPLVLA~~DDRSYKSYLMNGP~~ORIGRKYK~~KVRF~~MAYTDETFKTREAIQHESGIL
 G~~PLLY~~GEVGD~~TLLIIFKN~~ASRPYNIYPHGITD~~VRPLYSRRLPKGVKHLKDFPILPGEIFKYKWT~~VVEDGPTKSDPR
 CLTRY~~YSS~~FVNMERDLASGLIG~~PLLIC~~YKESVD~~GRNQIMSDKRN~~VILFSVFDENRSWYLTENIG~~RFLPN~~PAGVQLED
 PEF~~AS~~NIMHSINGYV~~FD~~SLQ~~LSVCLH~~EVAYWYILSIGA~~Q~~TDFLSVFFSGYTFKHKMVYEDT~~TL~~LF~~PF~~SGETVFM~~SME~~
 NPGLWLIGCHNSDFRNRGMTALLKVSSCDKNTGDY~~YEDSYEDI~~SAYLLSKNNAIEPR~~SFSQNSRHPSTRQKQFNATTI~~
 PENDIEKTD~~PFAHRT~~PMPKIQNVSSDLLMLLRQ~~SPTPHGLSLS~~DLQEA~~YETFSDD~~PSGAIDSNNSLSEM~~THFRP~~
 QLHHS~~GMVFT~~PESGLQLRLNEKLGTTAATEL~~KKLDFKVS~~STSNNLISTIPSDNLAAGTDNTSSLG~~PPS~~MPVHYDSQL
 DTTLFGK~~SSPL~~TESGGPLSLSEEN~~NDSKLLESGLMNSQ~~ESSWGKNV~~SSTESGR~~LFKGKRAHG~~PALLTKDNALFKVSI~~
 SLLKTNKTSNNSATNRKTHIDG~~PSLLIENS~~PSVWQNI~~LES~~DT~~EF~~KKVTPLIH~~DRMLMDKNATALRLNHMSN~~KTTSSKN
 MEMVQ~~QK~~KEGPIPPDAQNP~~DMSFFKMLFL~~PESARWIQRTHG~~KNSLNSGQ~~GPS~~PKQLVSLG~~PEKSVEGQ~~NFL~~SEKNKV
 VGKGEFTKDVGLKEMV~~FSSRN~~FLTNLDNLHEN~~NTHNQEKKI~~QEEIEK~~KETLIQEN~~VVLPQIHTVTG~~TKNFM~~KNLFL
 LSTRQ~~NVEGSYD~~GAYAPVLQDFRSL~~NDSTNR~~TKKHTAHFS~~KK~~GEEENLEGLGN~~QTKQ~~IVEKYACTTRIS~~PNTS~~QQNEV
 TQ~~RSKRAL~~KQFRLPLEETE~~LEKRI~~IVDDTSTQ~~WSKMKHLTPSTLTQ~~IDYNEKEKGAITQ~~SPLSDCLTRSHSIPQANR~~
 SPLPIAKV~~SSFP~~SIRPIYL~~TRVLE~~QDNSSHLPAAS~~YRKKD~~SGVQ~~ESSHFLQ~~GAKNNLSLA~~IL~~LTLEMTGDQ~~REV~~GSGL
 TSATNSV~~TYK~~VENTVLPK~~PDLPK~~TS~~SGK~~VELLPKVHIYQ~~KDLFP~~TETSNGSPGH~~LDL~~VEGSLLQ~~GTEGA~~IKWNEANRP
 GKVPFLRVATESAKT~~PSKLLDPLAWDNHYGTQ~~IPKEE~~WKSQ~~EKSPEKTA~~FKKKDTILSLNACESN~~HAAIAINEGQ~~NK~~
 PEIEVTWAKQGRTERLCSQ~~NPPV~~LKRHQREITR~~TTLQSDQEE~~IDYDDTISVEM~~KKEDFDIYDE~~DENQSPRSFQ~~KKTRH~~
 YFIAA~~VERL~~WDYGMSSPHVL~~NR~~AQSGSV~~PQFKV~~VQEF~~TDGSFTQ~~PLYRGELNEHLGLLGPYIRAE~~VEDN~~IMVTF
 RNQASRPYSFYSS~~LI~~SYEEDQ~~RQGA~~EPRKNFVKPNETKTY~~FWKVQHH~~MAPTKDE~~FDCKAWAY~~FSDVDLEKDVHSG~~LIG~~
 PLLVCH~~TNTLN~~PAHGRQVTVQ~~E~~FALFFTIFDE~~TKSWYFTENMERN~~CRAPCNIQ~~MEDPT~~FKENYRFHAIN~~GYIMD~~TLPG
 LVMAQDQIRWYLLSMG~~SNENIHS~~IHFSGHV~~FTVR~~KKEBYK~~MALYNLY~~PGVFETVEM~~LPSKAGIWR~~VECLIGEHLHAG
 MSTLFLV~~YSNKCQ~~TPLGMASGHIRD~~FQITASGQY~~QWAPKLARLHYS~~GSINAW~~STKEPFSWIKVDLLAPMIHGIKTQ
 GARQ~~KFSSLYISQFI~~IMYSLDGKKWQTYRGNSTG~~TLMVFFGN~~VDS~~SGIKHNI~~FNPPIARYIRLH~~PTHYSIR~~STLRME
 LMGCDLNSCSMPLG~~MESKAISDAQITASSYFT~~NMFATWSPSKARLHLQGRS~~NAWRPQV~~NNPKEWLQVDFQ~~TKM~~KVTGV
 TTQGVKSL~~LTSMYV~~KEFLISSSQDGHQ~~WTLFFQ~~NGKVKV~~FQGNQDS~~FTPV~~VNSLD~~PP~~LLTRYLR~~IHPQSV~~WHQIALRM~~
 EVLGCEAQ~~DLYDKTHT~~CP~~PC~~PAPELLGGPSV~~FLFP~~PKP~~DTLMI~~SRTPEV~~ICVVVDV~~SHEDPEVKFNWY~~VDG~~VEVHNA
 KTKPREEQYNSTYRVVSVLTVLHQD~~WLN~~NGKEYKCKVSNKALPAP~~IEKTISKAKGQ~~PREPQVY~~TLPPSR~~DELTKN~~QVSL~~
 TCLVKGFYPSDIAVEWESNGQ~~PENNYK~~TTPPVLDSDGSFFLYSKLTV~~DKSRWQQGNV~~FSCSV~~MHEALHNHYTQK~~SLSL
 SPGK

B(ii). Fc chain (20 amino acid heterologous signal peptide from mouse Igk chain underlined) (SEQ ID NO:4)

METDTLLLWVLLWVPGSTGDKTH~~TCPP~~CPAPELLGGPSV~~FLFP~~PKP~~DTLMI~~SRTPEV~~ICVVVDV~~SHEDPEVKFNWY
 VDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQD~~WLN~~NGKEYKCKVSNKALPAP~~IEKTISKAKGQ~~PREPQVY~~TLPPSR~~
 ELTKN~~QVSL~~TCLVKGFYPSDIAVEWESNGQ~~PENNYK~~TTPPVLDSDGSFFLYSKLTV~~DKSRWQQGNV~~FSCSV~~MHEALHN~~
 HYTQKSLSLSPGK

C. FVIII-Fc Heterodimer Hybrid

This is made by cotransfecting HC-Fc and LC-Fc constructs. Two HC-Fc constructs have been made. One has no linker between HC and Fc (HC-Fc) while the other has a 5 amino acid linker between HC and Fc (HC+5-Fc). The FVIII signal peptide was used for the HC-Fc constructs, while the mouse Igk signal sequence was used for the LC-Fc construct.

C(i). HC-Fc (Fc sequence is shown in bold, signal peptide underlined) (SEQ ID NO:8)

MQIELSTCFFLCLLRFCFSATRRYYLGAVELSDWYMQSDLGELPVDARFPPRVPKSFPFN**TSV**VVYKKTLFVEFTDHLF
 NIAKPRPPWMGLLGPTIQAEVYDVTVVITLKNMASHPVSLHAVGVSYWKASEGAEYDDQTSQREKEDDKVFPGGSHTYV
 WQVLKENGPMASDPLCLTYSYLSHVDLVKDLNSGLIGALLVCREGSLAKEKTQTLHKFILLFAVFDEGKSWHSETKNS
 LMQDRDAASARAWPKMHTVNGYVNRSLPGLIGCHRKSVYWHVIGMGTTPPEVHSIFLEGHTFLVRNHRQASLEISPIITF
 LTAQTLMLDLGQFLFCHISSHQHDGMEAYVKVDSCEPEEPQLRMKNNEEAEDYDDDLTDSEMDVVRFDDDNSPSFIQI
 RSVAKKHPKTWVHYIAAEEDWDYAPLVLAPDDRSYKSYLNNGPQRIGRKYKVRFMAYTDETFKTREAIQHESGIL
 GPLLYGEVGD~~TLLII~~IFKNQASRPYNIYPHGITDVRPLYSRRLPKGVKHLKDFPILPGEIFKYKWTVTVEDGPTKSDPR
 CLTRYSSFVNMERDLASGLIGPLLI~~ICYKESVDQRGNQ~~IMSDKRNILFSVFDENRSWYL~~TENIQRFLPNPAGVQLED~~
 PEFQASNIMHSINGYVFDLQSVCLHEVAYWYILSIGAQTD~~FLSVFFSGYTFKHKM~~VYEDTLTLFPFSGETVFM~~SME~~
 NPGLWILGCHNSDFRNRGMTALLKVSSCDKNTGDYEDSYEDISAYLLSKNNAIEPRDKTHTCPCPAPELLGGPSVFL
 FPPPKPDTLMI~~SRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYN~~STYRVVSVLTVLHQDWLNGKEY
 KCKVSNKALPAPIEKTI~~SKAKGQPREPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWE~~SNGQPENNYKTTPPV
 L~~SDSGSFFLYSKLTVDKSRWQQGNV~~FSCSVMEALHNHYTQKSLSLSPGK

C(ii). HC+5-Fc (Fc sequence is shown in bold, 5 amino acid linker sequence (from the B domain of FvIII) is shown in italics (boxed), signal peptide underlined.)(SEQ ID NO:10)

MQIELSTCFFLCLLRFCFSATRRYYLGAVELSDWYMQSDLGELPVDARFPPRVPKSFPFN**TSV**VVYKKTLFVEFTDHLF
 NIAKPRPPWMGLLGPTIQAEVYDVTVVITLKNMASHPVSLHAVGVSYWKASEGAEYDDQTSQREKEDDKVFPGGSHTYV
 WQVLKENGPMASDPLCLTYSYLSHVDLVKDLNSGLIGALLVCREGSLAKEKTQTLHKFILLFAVFDEGKSWHSETKNS
 LMQDRDAASARAWPKMHTVNGYVNRSLPGLIGCHRKSVYWHVIGMGTTPPEVHSIFLEGHTFLVRNHRQASLEISPIITF
 LTAQTLMLDLGQFLFCHISSHQHDGMEAYVKVDSCEPEEPQLRMKNNEEAEDYDDDLTDSEMDVVRFDDDNSPSFIQI
 RSVAKKHPKTWVHYIAAEEDWDYAPLVLAPDDRSYKSYLNNGPQRIGRKYKVRFMAYTDETFKTREAIQHESGIL
 GPLLYGEVGD~~TLLII~~IFKNQASRPYNIYPHGITDVRPLYSRRLPKGVKHLKDFPILPGEIFKYKWTVTVEDGPTKSDPR
 CLTRYSSFVNMERDLASGLIGPLLI~~ICYKESVDQRGNQ~~IMSDKRNILFSVFDENRSWYL~~TENIQRFLPNPAGVQLED~~
 PEFQASNIMHSINGYVFDLQSVCLHEVAYWYILSIGAQTD~~FLSVFFSGYTFKHKM~~VYEDTLTLFPFSGETVFM~~SME~~
 NPGLWILGCHNSDFRNRGMTALLKVSSCDKNTGDYEDSYEDISAYLLSKNNAIEPR**SFSQ**DKTHTCPCPAPELLG
 GPSVFLFPPPKPDTLMI~~SRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYN~~STYRVVSVLTVLHQDWL
 NGKEYKCKVSNKALPAPIEKTI~~SKAKGQPREPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWE~~SNGQPENNYK
 TTPPVLDSDSGSFFLYSKLTVDKSRWQQGNV**FSCSVMEALHNHYTQKSLSLSPGK**

C(iii). LC-Fc6His (Fc sequence is shown in bold, signal peptide underlined.) (SEQ ID NO:12)

METDTLLLWVLLWVPGSTGEITR~~TTLQSDQEEIDYDDTISVEMK~~KEDFDIYDEDENQSPRSFQKKTRHYFIAAVERL
 WDYGMS~~SSPHVLRNRAQSGSV~~PQFKVVFQEF~~TDG~~SFTQPLYRGELNEHLGLLGPYIRAEVEDNIMVTFRNQASRPYS
 FYSSLISYEEDQRQGAEPK~~NFVKPNETKTYFWKVQH~~MAPTKDEFDCKAWAYFSDVDLEKDVHSGLIGPLLVCHTNT
 LNPAGHRQVTVQEFALFF~~TFIDETKSWYFTENMERNCRAPCNIQMEDPTFKENYRFHA~~INGYIMDTLPGLVMAQDQRI
 RWYLLSMG~~SNENIHSIHFSGHVFTVRKKEEYK~~MALYNLYPGVFETVEMLPSKAGIWRVECLIGEHLHAGMSTLFLVYS
 NKCQTPLG~~MASGHIRD~~FQITASGQYQWAPKLARLHYSGSINAWSTKEPFSWIKVDLLAPMIHGIKTQGARQKFSSL
 YISQFIIMYSLDGK~~KWQTYRGNSTGTL~~MVFFGNVDSSGIKHNI~~FNPP~~IARYIRLHPHYSIRSTLRMELMGCDLNSC
 SMPLG~~MESKAI~~SDAQITASSYFTNM~~FATWSPSKARLHLQGR~~SNAWRPQVNNPKEWLQVDFQKTMKVTGVTQGVKSL
 TSMYVKEFLISSSQDGHQWTLFFQNGKVKVFQGNQDSFTPVVNSLDPPL~~LTRYLR~~IHFQSWVHQIALRMEVLGCEAQD
 LYDKTHTCPCPAPELLGGPSVFLFPPPKPDTLMI~~SRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQY~~
 NSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTI~~SKAKGQPREPQVYTLPPSRDELTKNQVSLTCLVKGFYPSDIAVEWE~~
 SNGQPENNYKTTPPVLDSDSGSFFLYSKLTVDKSRWQQGNV**FSCSVMEALHNHYTQKSLSLSPGK**

D. FIX-Fc chain (SEQ ID NO:14):

(28 amino acid signal sequence underlined, 18 amino acid propeptide double underlined, Fc portion in italics.) The C-terminal lysine is not present in either subunit; this processing is often observed in recombinant proteins produced in mammalian cell culture, as well as with plasma derived proteins.

E. FIXFc-SC subunit:

FIX Signal Peptide :

- 46 MQRVNMIMAESPGLITICLLGYLLSAEC

FIX Propeptide : -18 TVFLDHENAN KILNRPKR

YNSGKLEEFVQGNLERECMEEKCSFEEAREVFENTERTEFEWKQYVDGDQCESNPCLNGGSCKDDINSYECWCPFGFE
GKNCELDVTCNIKNGRCEQFCCKNSADNKVVCSCTEGYRLAENQKSCEPAVFPFCGRVSVSQTSKLTRAETVFPDVDYV
NSTEAETILDNITQSTQSFNDFTRVVGGEDAKPGQFPWQVVLNGKVDAFCGGSIVNEKWIIVTAAHCVETGVKITVVAG
EHNIEETEHTEQKRNVIIRIIPHHNYNAAINKYNHDIALLELDEPLVLNSYVTPICIAADKEYTNI FLKFGSGYVSGWGR
VFHKGRSALVLQYLRVPLVDRATCLRSTKFTIYNNMFCAGFHEGGRDSCQGDSSGGPHVTEVEGTSFLTGIISWGEECA
MKGKYGITYTKVSRYVNWIKKTKLTDKHTCPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEV
KFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTL
PPSRDELTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCVMH
EALHNHYTQKSLSLSPGK

Mature Fc sequence (corresponding to human IgG1 amino acids 221 to 447, EU numbering)

DKHTCPCPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNS
TYRVVSVLTVLHQDWLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSRDELTKNQVSLTCLVKGFYPSD
IAVEWESNGQPENNYKTPPVLDSDGSFFLYSKLTVDKSRWQQGNVFCVMHEALHNHYTQKSLSLSPGK

WHAT IS CLAIMED IS:

1. A composition for the measurement of coagulation factor activity in a sample comprising an activated coagulation factor and a phospholipid mixture, wherein the composition is dried onto a solid substrate.
2. A composition for the measurement of coagulation time in a sample comprising an activated coagulation factor and a phospholipid mixture, wherein the composition is dried onto a solid substrate.
3. The composition of any one of claims 1 or 2, wherein the solid substrate is selected from the group consisting of paper, plastic, glass, ceramic material, metal, and combinations thereof.
4. The composition of any one of claim 1 or 2, wherein the solid substrate is a surface on a test strip, test stick, reaction chamber, cartridge, chip, well plate, or array used in an apparatus to measure coagulation factor activity or coagulation time.
5. The composition of any one of claims 1 to 4, wherein the coagulation factor is selected from the group consisting of FVII, FVIII, and FIX.
6. The composition of any one of claims 1 to 4, wherein the coagulation factor is a Factor VIII protein or a fragment, variant, or derivative thereof.
7. The composition of any one of claims 1 to 4, wherein the coagulation factor is a Factor IX protein or a fragment, variant, or derivative thereof.
8. The composition of claim 6, wherein the activated coagulation factor is a Factor IXa protein or a fragment, variant, or derivative thereof.
9. The composition of claim 8, wherein Factor IXa is present in the composition prior to drying within a range of 0.01 to 0.05 U/mL
10. The composition of claim 7, wherein the activated coagulation factor is a Factor XIa protein or a fragment, variant, or derivative thereof.
11. The composition of claim 10, wherein Factor XIa is present in the composition prior to drying within a range of 0.01 to 0.05 U/mL
12. The composition of any one of claims 1 to 11, wherein the phospholipid mixture comprises 2 phospholipids.
13. The composition of any one of claims 1 to 12, wherein the phospholipid mixture comprises 3 phospholipids.

14. The composition of any one of claims 1 to 13, wherein the phospholipids are selected from the group consisting of phosphatidylcholine, phosphatidylserine, phosphatidylglycerol, and combinations thereof.

15. The composition of any one of claims 1 to 14, wherein the phospholipids are natural phospholipids, synthetic phospholipids, or combinations thereof.

16. The composition of claim 12, wherein the phospholipid mixture comprises 70 mole-% of phosphatidylcholine and 30 mole-% of phosphatidylserine.

17. The composition of claim 13, wherein the phospholipid mixture comprises 80 mole-% of phosphatidylcholine, 10 mole-% of phosphatidylserine, and 10 mole-% of phosphatidylglycerol.

18. The composition of claim 13, wherein the phospholipid mixture comprises 75 mole-% of phosphatidylcholine, 20 mole-% of phosphatidylserine, and 5 mole-% of phosphatidylglycerol.

19. The composition of any one of claim 1 to 15, wherein the phospholipid mixture further comprises cholesterol.

20. The composition of claim 19, wherein the cholesterol content in the phospholipid mixture is from about 1 to about 20 mole-% of cholesterol.

21. The composition of any one of claims 1 to 20, wherein the phospholipid mixture is in vesicle form.

22. The composition of claim 21, wherein the vesicles are small unilamellar vesicles.

23. The composition of any one of claims 1 to 22, further comprising divalent cations.

24. The composition of claim 23, wherein the divalent cations are calcium ions.

25. The composition of any one of claims 1 to 24, wherein the sample is selected from the group consisting of whole blood, citrated or equivalently stabilized blood, plasma, or other fluid sample containing or suspected of containing a coagulation factor.

26. The composition of claim 25, wherein the sample is decalcified.

27. The composition of any one of claims 1 to 26, wherein the measurement is carried in a point of care test system.

28. The composition of any one of claims 1 to 26, wherein the measurement is carried out in a mechanical or optical analytical system.

29. A composition for the measurement of the Factor VIII activity of a Factor VIII protein or a fragment, variant, or derivative thereof in a sample comprising 80% of 0.1 mg/mL

Factor IXa and 20% of a phospholipid mixture comprising 75 mole-% of phosphatidylcholine, 20 mole-% of phosphatidylserine, and 5 mole-% of phosphatidylglycerol, wherein said composition is dried onto a solid substrate.

30. A composition for the measurement of the Factor IX activity of a Factor IX protein or a fragment, variant, or derivative thereof in a sample comprising 80% of a Factor X_{ia} suspension at about 0.1-0.5 mg/mL and 20% of a phospholipid mixture comprising 75 mole-% of phosphatidylcholine, 20 mole-% of phosphatidylserine, and 5 mole-% of phosphatidylglycerol, wherein said composition is dried onto a solid substrate.

31. A kit for performing a measurement of coagulation factor activity or coagulation time in a sample comprising the composition of any one of claims 1 to 30 in one or more vials.

32. A kit for performing a measurement of coagulation factor activity or coagulation time in a sample comprising the composition of any one of claims 1 to 30 in a non-dry form in one or more vials and instructions for drying said composition onto a solid substrate.

33. A sample holder for performing a blood coagulation assay, comprising a surface coated with the composition of any one of claims 1 to 30.

34. The sample holder of claim 33, wherein the sample holder is selected from the group consisting of a test strip, a test stick, a reaction chamber, a cartridge, a chip, a well plate, and an array.

35. A method for determining clotting time in a patient having a bleeding disorder, comprising:

(a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate; and,

(b) measuring the time between the contacting of the activation mixture with the blood sample and the onset of clotting, thereby calculating the clotting time (Ct).

36. A method of treating a patient having a bleeding disorder comprising:

(a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate;

(b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct), wherein Ct indicates whether the patient will benefit from administration of a treatment; and,

(c) administering the treatment to the patient if Ct indicates that the patient will benefit from administration of the treatment.

37. A method of treating a patient having a bleeding disorder comprising:

(a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate;

(b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct), wherein Ct indicates whether the patient will benefit from administration of a treatment; and,

(c) instructing a healthcare provider to administer the treatment to the patient if Ct indicates that the patient will benefit from administration of the treatment.

38. A method of optimizing a bleeding disorder treatment in a patient comprising:

(a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate;

(b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct), wherein Ct correlates with a therapeutically efficacious treatment; and,

(c) administering an optimized treatment to the patient, wherein the treatment is maintained or adjusted.

39. A method of optimizing a bleeding disorder treatment in a patient comprising:

(a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate;

(b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct), wherein Ct correlates with a therapeutically efficacious treatment; and,

(c) instructing a healthcare provider to optimize the treatment administered, wherein the treatment is maintained or adjusted.

40. A method of diagnosing whether a patient is in need of treatment for a bleeding disorder comprising:

(a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate;

(b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct), wherein Ct indicates whether the patient has a bleeding disorder; and,

(c) providing a treatment for the bleeding disorder if the patient is in need thereof.

41. A method of diagnosing whether a patient is in need of treatment for a bleeding disorder comprising:

(a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate;

(b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct), wherein Ct indicates whether the patient has a bleeding disorder; and,

(c) instructing a healthcare provider to provide treatment for the bleeding disorder if the patient is in need thereof.

42. A method of monitoring the efficacy of a bleeding disorder treatment administered to a patient comprising:

(a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate;

(b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); and,

(c) comparing the measured Ct with the Ct obtained from a corresponding standard, wherein the standard is representative of a therapeutically efficacious treatment, and wherein a similarity between the patient's results and the standard is indicative of efficacy of the patient's current treatment; and,

(d) maintaining or adjusting the patient's treatment based on the relative difference between the patient's results and the corresponding standard.

43. A method of monitoring the efficacy of a bleeding disorder treatment administered to a patient comprising:

(a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate;

(b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); and,

(c) comparing the measured Ct with the Ct obtained from a corresponding standard, wherein the standard is representative of a therapeutically efficacious treatment, and wherein a similarity between the patient's results and the standard is indicative of efficacy of the patient's current treatment; and,

(d) instructing a healthcare provider to maintain or adjusting the patient's treatment based on the relative difference between the patient's results and the corresponding standard.

44. A method for determining a coagulation factor level in a bleeding disorder patient, comprising:

(a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate;

(b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); and,

(c) correlating the Ct value with the level of coagulation factor in the sample.

45. The method of claim 44, wherein the correlation between Ct and coagulation factor level (%Factor) is calculated according to the formula:

$$Ct = A \times \ln(\%Factor) + B \quad [\text{Formula I}]$$

wherein, for each coagulation factor, A is a constant value corresponding to the slope of a Ct versus coagulation factor concentration dose-response, and B is patient-specific off-set value.

46. A method for determining a pharmacokinetic (PK) parameter in a bleeding disorder patient, comprising:

(a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate;

(b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); and,

(c) correlating a PK with the calculated Ct value, thereby determining the value of the PK parameter.

47. A method of treating a patient having a bleeding disorder comprising:

(a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate;

(b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct);

(c) determining a PK parameter based on Ct, wherein the PK parameter indicates that the patient will benefit from administration of the treatment; and,

(d) administering the treatment to the patient if the PK parameter indicates that the patient will benefit from administration of the treatment.

48. A method of treating a patient having a bleeding disorder comprising:

(a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate;

(b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct);

(c) determining a PK parameter based on Ct, wherein the PK parameter indicates that the patient will benefit from administration of the treatment; and,

(d) instructing a healthcare provider to administer the treatment to the patient if the PK parameter indicates that the patient will benefit from administration of the treatment.

49. A method of optimizing a bleeding disorder treatment in a patient comprising:

(a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate;

(b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct);

(c) determining a PK parameter based on Ct, wherein the PK parameter correlates with a therapeutically efficacious treatment; and,

(d) administering an optimized treatment to the patient, wherein the treatment is maintained or adjusted.

50. A method of optimizing a bleeding disorder treatment in a patient comprising:
- (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate;
 - (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct);
 - (c) determining a PK parameter based on Ct, wherein the PK parameter correlates with a therapeutically efficacious treatment; and,
 - (d) instructing a healthcare provider to administer an optimized treatment to the patient, wherein the therapy is maintained or adjusted.
51. A method of diagnosing whether a patient is in need of treatment for a bleeding disorder comprising:
- (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate;
 - (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); and,
 - (c) determining a PK parameter based on Ct, wherein the PK parameter indicates whether the patient has a bleeding disorder; and,
 - (d) providing treatment for the bleeding disorder if the patient is in need thereof.
52. A method of diagnosing whether a patient is in need of treatment for a bleeding disorder comprising:
- (a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate;
 - (b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); and,
 - (c) determining a PK parameter based on Ct, wherein the PK parameter indicates whether the patient has a bleeding disorder; and,
 - (d) instructing a healthcare provider to provide therapy to treat the bleeding disorder if the patient is in need thereof.

53. A method of monitoring the efficacy of a bleeding disorder treatment administered to a patient comprising:

(a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate;

(b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct); and,

(c) determining a PK parameter based on Ct;

(d) comparing the PK parameter with the PK obtained from a corresponding standard, wherein the standard is representative of a therapeutically efficacious treatment, and wherein a similarity between the patient's results and the standard is indicative of efficacy of the patient's current treatment; and,

(e) maintaining or adjusting the patient's treatment based on the relative difference between the patient's results and the corresponding standard.

54. A method of monitoring the efficacy of a bleeding disorder treatment administered to a patient comprising:

(a) contacting a sample obtained from the patient with an activation mixture comprising an activated coagulation factor and a phospholipid mixture, wherein the activation mixture is dried onto a solid substrate;

(b) measuring the time between the contacting of the activation mixture with the sample and the onset of clotting, thereby calculating the clotting time (Ct);

(c) determining a PK parameter based on Ct;

(d) comparing the PK parameter with the PK obtained from a corresponding standard, wherein the standard is representative of a therapeutically efficacious treatment, and wherein a similarity between the patient's results and the standard is indicative of efficacy of the patient's current treatment; and,

(e) instructing a healthcare provider to maintain or adjust the patient's treatment based on the relative difference between the patient's results and the corresponding standard.

55. The method of any one of claims 46 to 53, wherein the PK is terminal half-life (HL).

56. The method of any one of claims 46 to 53, wherein the PK is time to through (T).

57. The method of claim 55, wherein HL is calculated according to the formula:

$$HL = -0.693 \times (T_2 - T_1) \times A / (Ct_1 - Ct_2) \quad [\text{Formula II}]$$

wherein, for each coagulation factor, A is a constant value corresponding to the slope of a Ct versus coagulation factor concentration dose-response, T₁ and T₂ are times at which Ct is measured, and Ct₁ and Ct₂ are Ct values measured at T₁ and T₂, respectively.

58. The method of claim 56, wherein T is calculated according to the formula:

$$T = -1.44 \times HL / (A \times (Ct_{\text{measured}} - Ct_{\text{trough}})) \quad [\text{Formula III}]$$

wherein for each coagulation factor A is a constant value corresponding to the slope of a Ct versus coagulation factor concentration dose-response, and HL is the terminal half-life, Ct_{measured} is Ct measured at certain time point, and Ct_{trough} is patient-specific clot time at trough.

59. The method of claim 58, wherein the patient is administered a new dose of coagulation factor every T interval.

60. The method of any one of claims 35 to 59, wherein the sample is selected from the group consisting of whole blood, citrated or equivalently stabilized blood, plasma, or other fluid sample containing or suspected of containing a coagulation factor.

61. The method of any one of claims 35 to 59, wherein said sample is whole blood.

62. The method of claim 61, wherein the blood is venous blood.

63. The method of claim 61, wherein the blood is fingerstick blood.

64. The method of any one of claims 35 to 59, wherein said sample is plasma.

65. The method of any one of claims 35 to 59, wherein the sample is frozen and thawed prior to contacting the sample with the activation mixture.

66. The method of any one of claims 35 to 59, wherein the sample is has not been frozen and thawed prior to contacting the sample with the activation mixture.

67. The method of any one of claims 35 to 66, wherein the sample is decalcified.

68. The method of claim 67, wherein the decalcified sample is recalcified prior to contacting the sample with the activation mixture.

69. The method of claim 67, wherein the decalcified sample is recalcified after contacting the sample with the activation mixture.

70. The method of any one of claims 35 to 69, wherein the sample further comprises an added purified coagulation factor.

71. The method of any one of claims 35 to 70, wherein the sample further comprises an added inhibitor.

72. The method of claim 70, wherein the purified coagulation factor is selected from the group consisting of Factors II, Factor VII, Factor VIII, Factor IX, Factor X, Factor XI, Factor XII, Factor XIII, Fibrinogen, vWF, Tissue Factor, and combinations thereof.

73. The method of claim 71, wherein the inhibitor is selected from the group consisting of CTI, aprotinin, ϵ -aminocaproic acid (EACA), D-Phenylalanyl-l-prolyl-l-arginine chloromethyl ketone-Factor VIIa (FPRCK-FVIIa), anti-coagulation factor monoclonal antibodies, and combinations thereof.

74. The method of any one of claims 35 to 73, wherein the sample is diluted with substrate sample.

75. The method of claim 74, wherein one part of sample is diluted with three parts of substrate sample.

76. The method of any one of claims 35 to 75, wherein the activated coagulation factor is a Factor IXa protein or a fragment, variant, or derivative thereof.

77. The method of claim 76, wherein Factor IXa is present in the composition prior to drying within a range of 0.01 to 0.05 U/mL.

78. The method of any one of claims 35 to 75, wherein the activated coagulation factor is a Factor XIa protein or a fragment, variant, or derivative thereof.

79. The method of claim 78, wherein Factor XIa is present in the composition prior to drying within a range of 0.01 to 0.05 U/mL.

80. The method of any one of claims 35 to 79, wherein the phospholipid mixture comprises 2 phospholipids.

81. The method of any one of claims 35 to 79, wherein the phospholipid mixture comprises 3 phospholipids.

82. The method of any one of claims 35 to 81, wherein the phospholipids in the phospholipid mixture are selected from the group consisting of phosphatidylcholine, phosphatidylserine, phosphatidylglycerol, and combinations thereof.

83. The method of any one of claims 35 to 82, wherein the phospholipids are natural phospholipids, synthetic phospholipids, or combinations thereof.

84. The method of claim 80, wherein the phospholipid mixture comprises 70 mole-% of phosphatidylcholine and 30 mole-% of phosphatidylserine.

85. The method of claim 81, wherein the phospholipid mixture comprises 80 mole-% of phosphatidylcholine, 10 mole-% of phosphatidylserine, and 10 mole-% of phosphatidylglycerol.

86. The method of claim 82, wherein the phospholipid mixture comprises 75 mole-% of phosphatidylcholine, 20 mole-% of phosphatidylserine, and 5 mole-% of phosphatidylglycerol.

87. The method of any one of claims 35 to 86, wherein the phospholipid mixture further comprises cholesterol.

88. The method of claim 87, wherein the cholesterol content in the phospholipid mixture is from about 1 to about 20 mole-% of cholesterol.

89. The method of any one of claims 35 to 88, wherein the phospholipid mixture is in lipid vesicle form.

90. The method of claim 89, wherein the lipid vesicles are small unilamellar vesicles.

91. The method of any one of claims 35 to 90, wherein the activation mixture further comprises divalent cations.

92. The method of claim 91, wherein the divalent cations are calcium ions.

93. The method of any one claims 35 to 92, wherein the activation mixture reacts with a coagulation factor selected from the group consisting of Factor VII, Factor VIII, and Factor IX.

94. The method of claim 93, wherein the Factor VIII coagulation factor is a Factor VIII protein or a fragment, variant, or derivative thereof.

95. The method of claim 93, wherein the Factor IX coagulation factor is a Factor IX protein or a fragment, variant, or derivative thereof.

96. The method of claim 93, wherein the Factor VIII coagulation factor is a chimeric Factor VIII-Fc fusion protein

97. The method of claim 93, wherein the Factor IX coagulation factor is a chimeric Factor IX-Fc fusion protein.

98. The method of any one of claims 96 or 97, wherein the Fc portion of the chimeric Factor VIII or Factor IX protein comprises a human Fc domain.

99. The method of claim 96, wherein the chimeric Factor VIII protein comprises a B-domain deleted Factor VIII.

100. The method of any one of claims 94, 96 or 98, wherein the chimeric Factor VIII protein comprises SEQ ID NO:6.

101. The method of claim any one of claims 94, 96, 98, or 99, wherein the chimeric Factor VIII protein comprises SEQ ID NO:2.

102. The method of any one of claims 95, 97 or 98, wherein the chimeric Factor IX protein comprises SEQ ID NO: 13.

103. The method of any one of claims 35 or 102, wherein the solid substrate is selected from the group consisting of paper, plastic, glass, ceramic material, metal, and combinations thereof.

104. The method of any one of claim 35 or 102, wherein the solid substrate is a surface on a test strip, test stick, reaction chamber, cartridge, chip, well plate, or array used in an apparatus to measure coagulation factor activity or coagulation time.

105. The method of any one of claims 35 to 102, wherein the patient has not yet been treated with a coagulation factor.

106. The method of any one of claims 35 to 105, wherein the patient has received prior coagulation factor treatment, but the treatment has been discontinued for a time period sufficient to deplete the coagulation factor treatment from the patient's blood.

107. The method of any one of claims 35 to 106, wherein the measurement is carried in a point of care test system.

108. The method of any one of claims 35 to 107, wherein the measurement is carried out in a mechanical or optical analytical system.

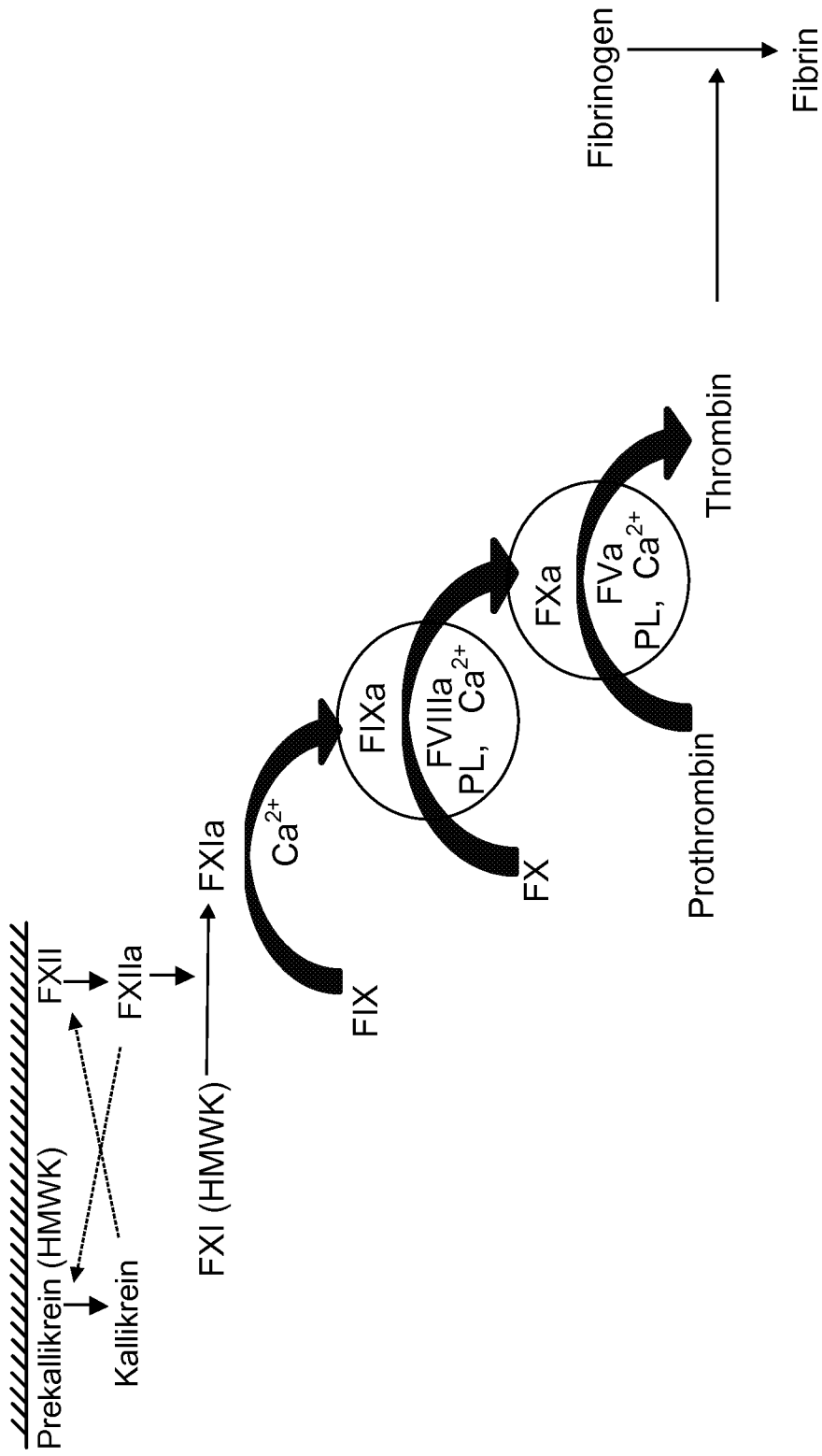
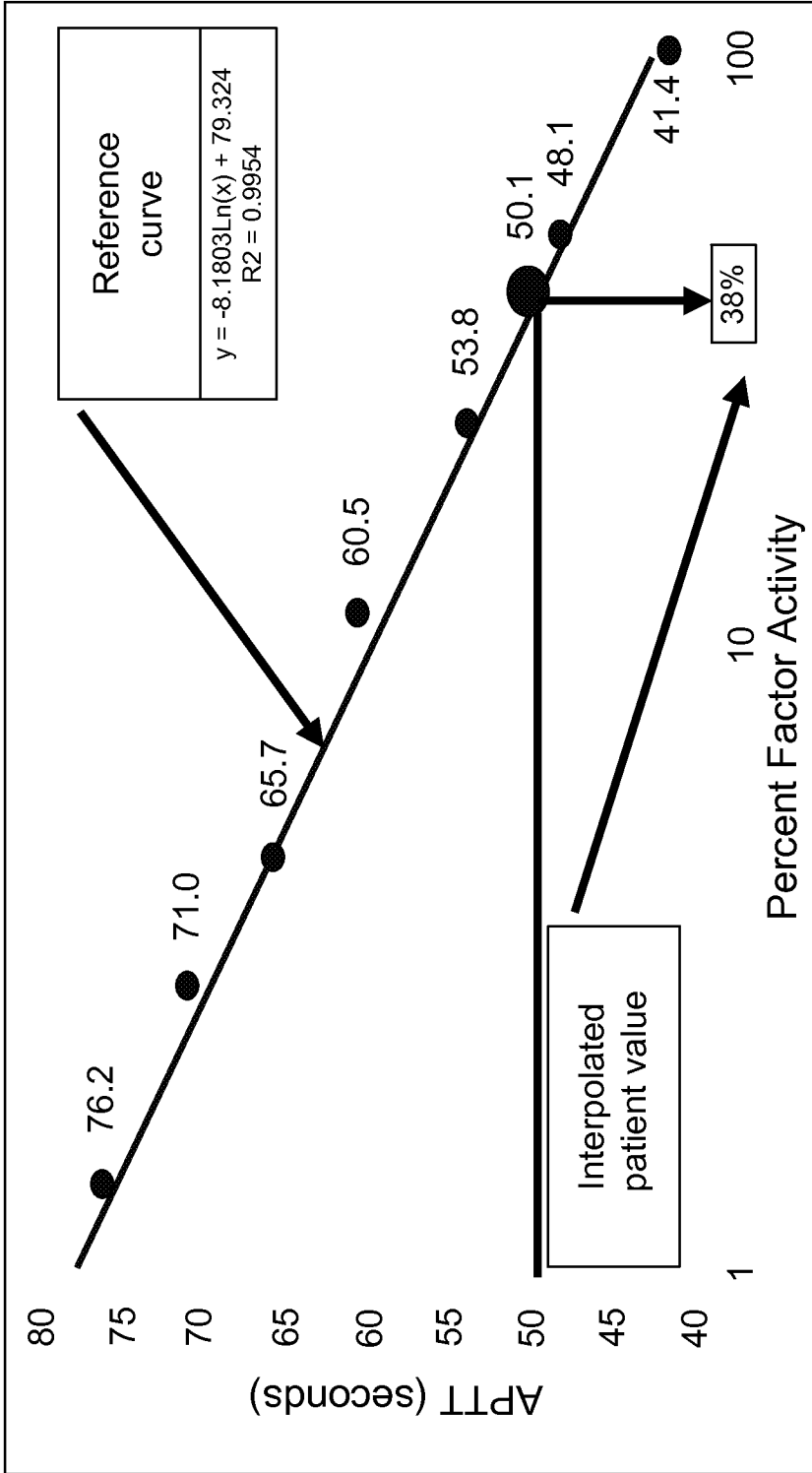


FIG. 1



Reference Dilution	% FVIII	Seconds
	X (log)	Y (lin)
1:10	92	41.4
1:20	46	48.1
1:40	23	53.8
1:80	11.5	60.5
1:160	5.7	65.7
1:320	2.9	71.0
1:640	1.4	76.2

Sample:
 1 Part Diluted Patient Sample
 1 Part Factor Deficient Plasma - Incubate 5 minutes at 37°
 1 Part APTT Reagent
 1 Part CaCl₂
Standard
 Normal Pooled Plasma Calibrated against an International Reference Plasma

FIG. 2

Hem A Donor Plasma Spiked with rFVIII-Fc

-Useful range: 0.8 – 100 IU/dL

-Average CV = 3.8%

-Average Spike Recovery = +/- 9.9% of nominal

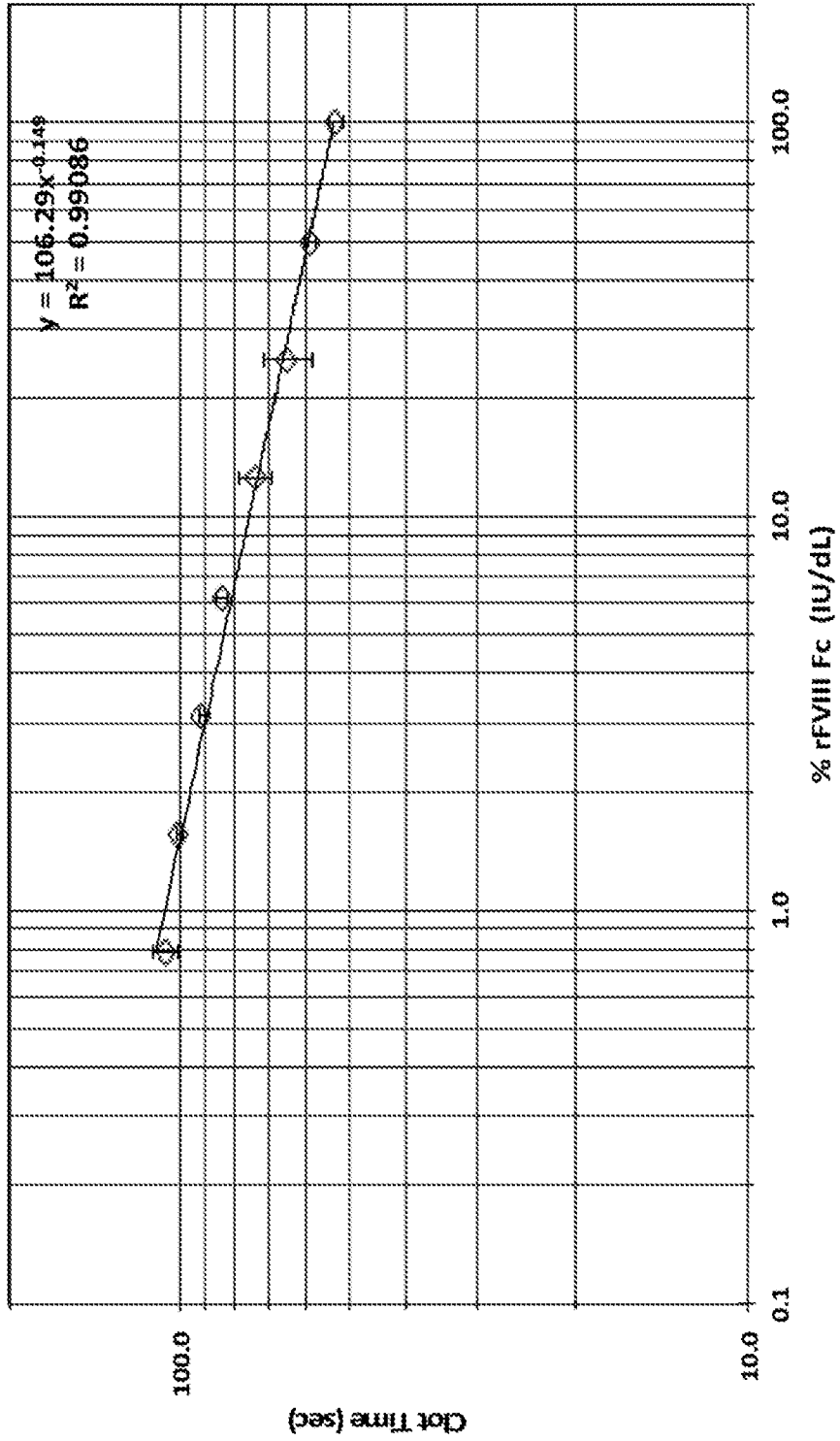


FIG. 3

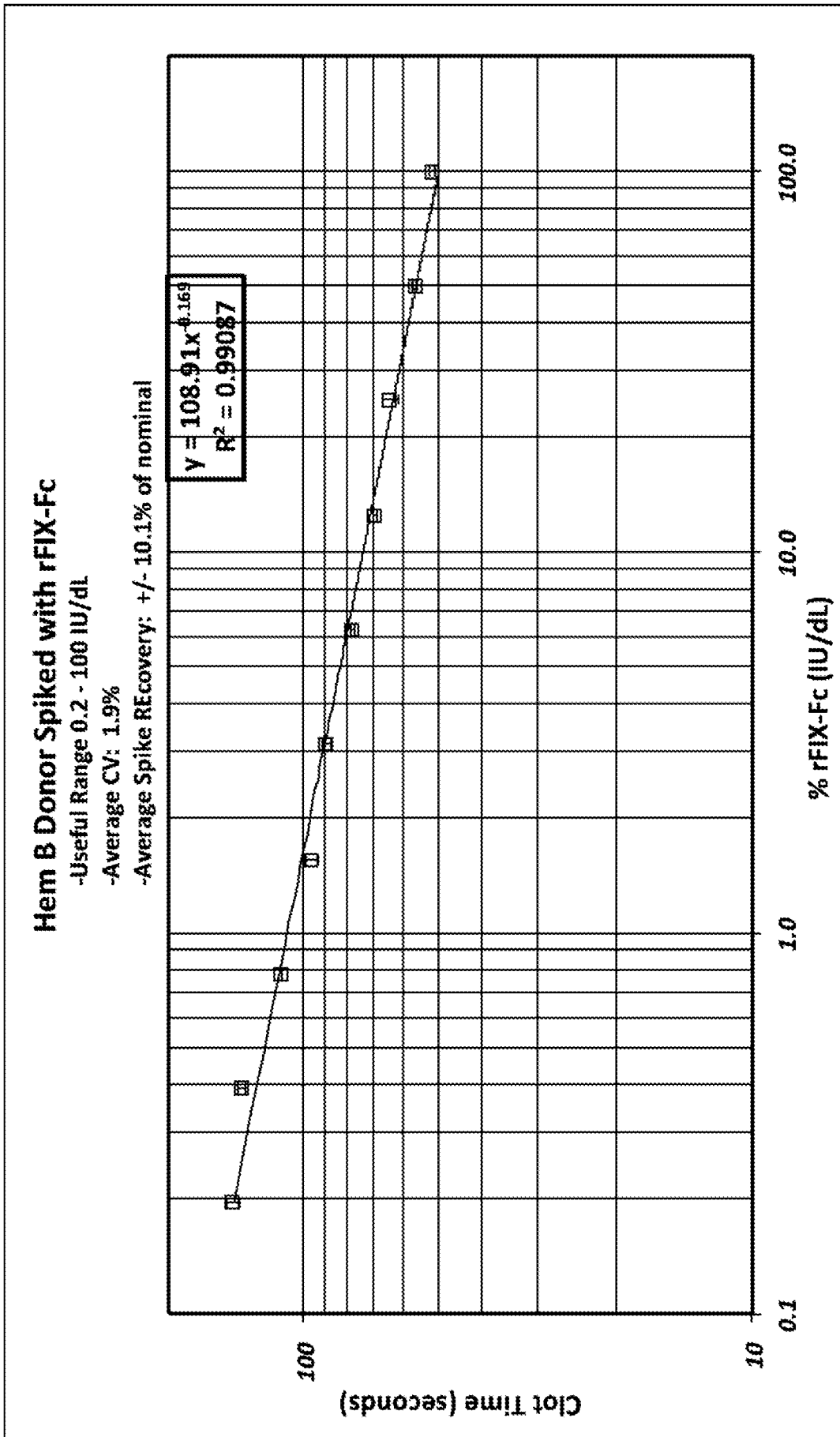


FIG. 4

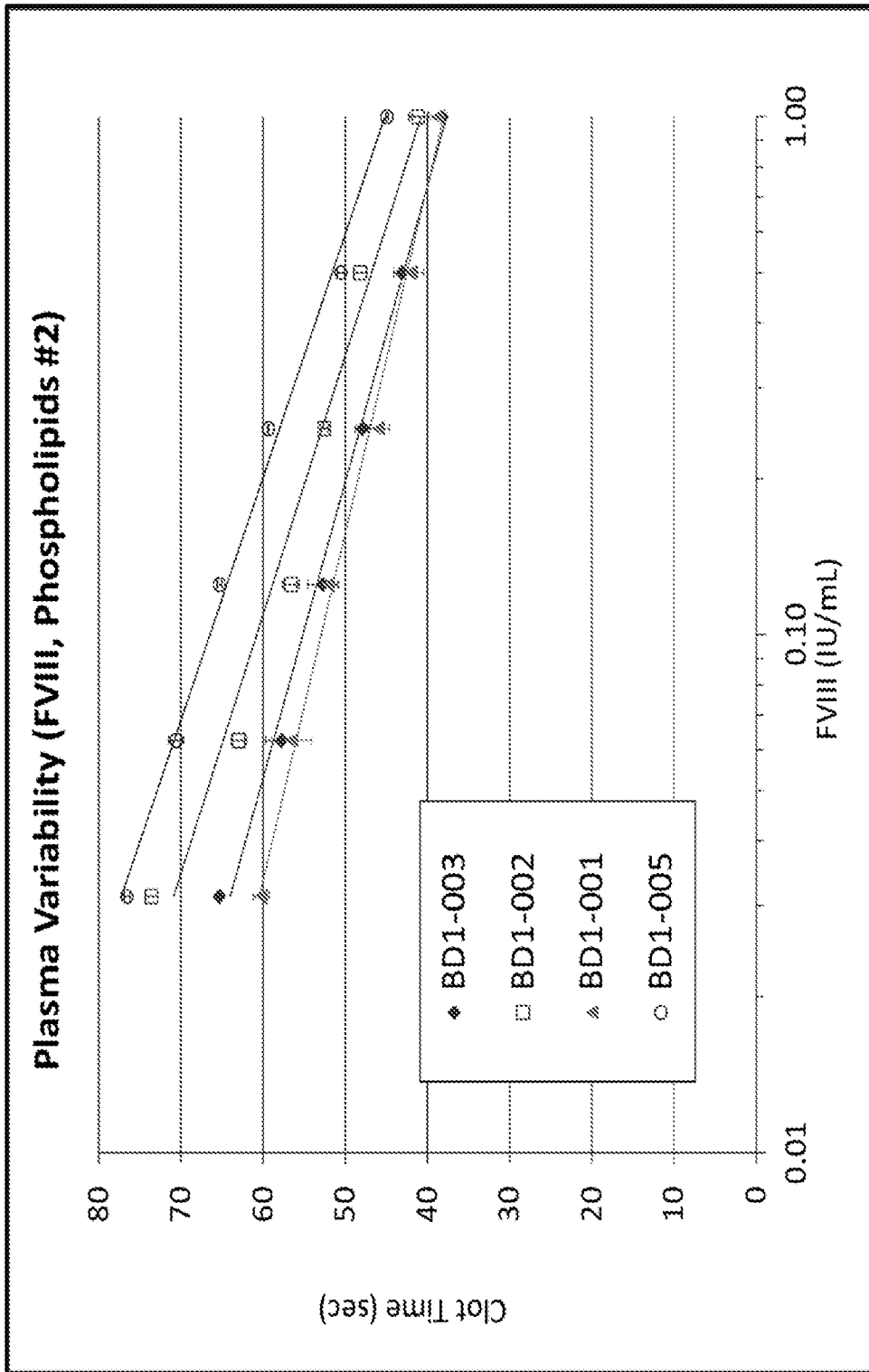


FIG. 5A

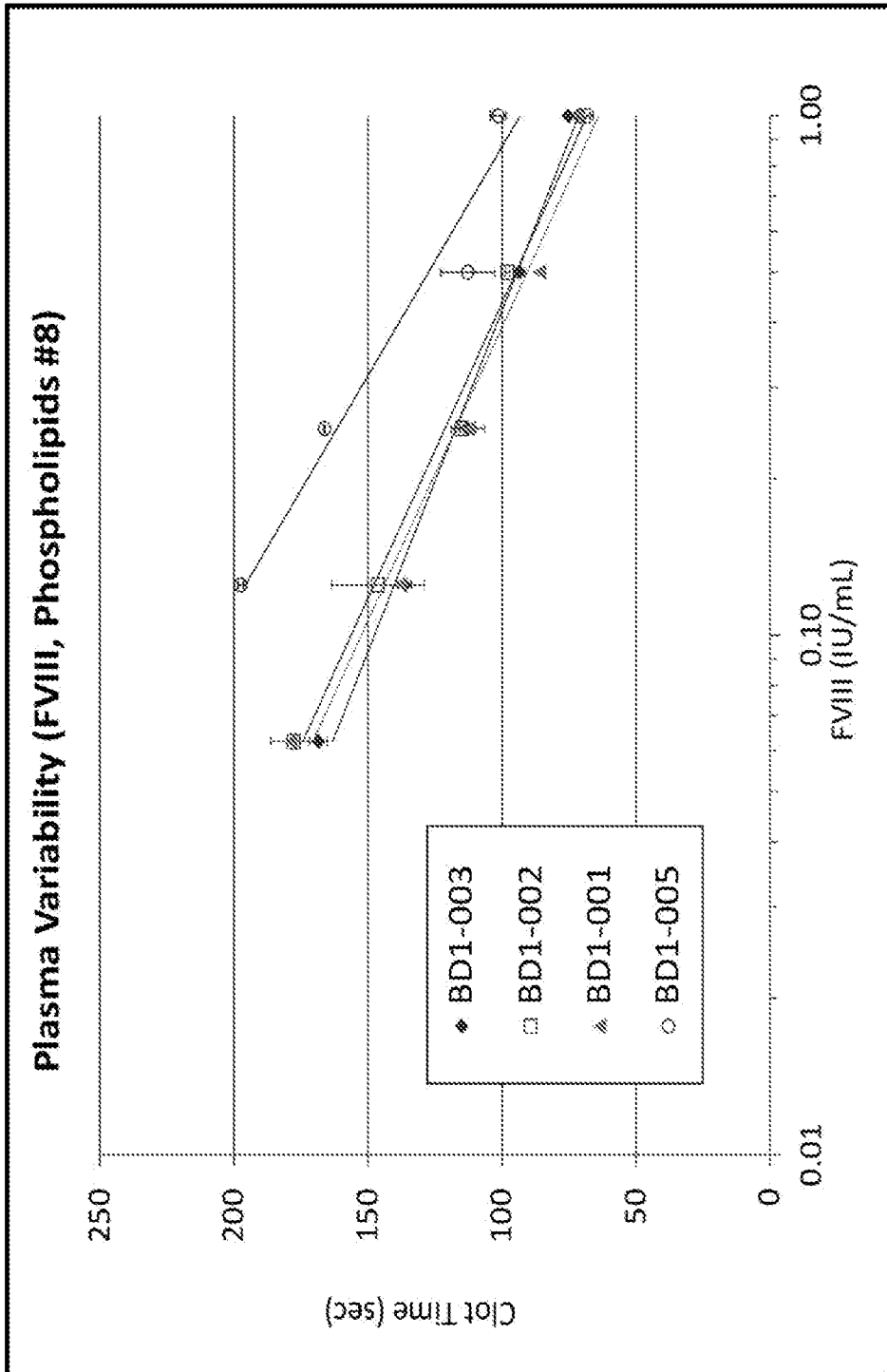


FIG. 5B

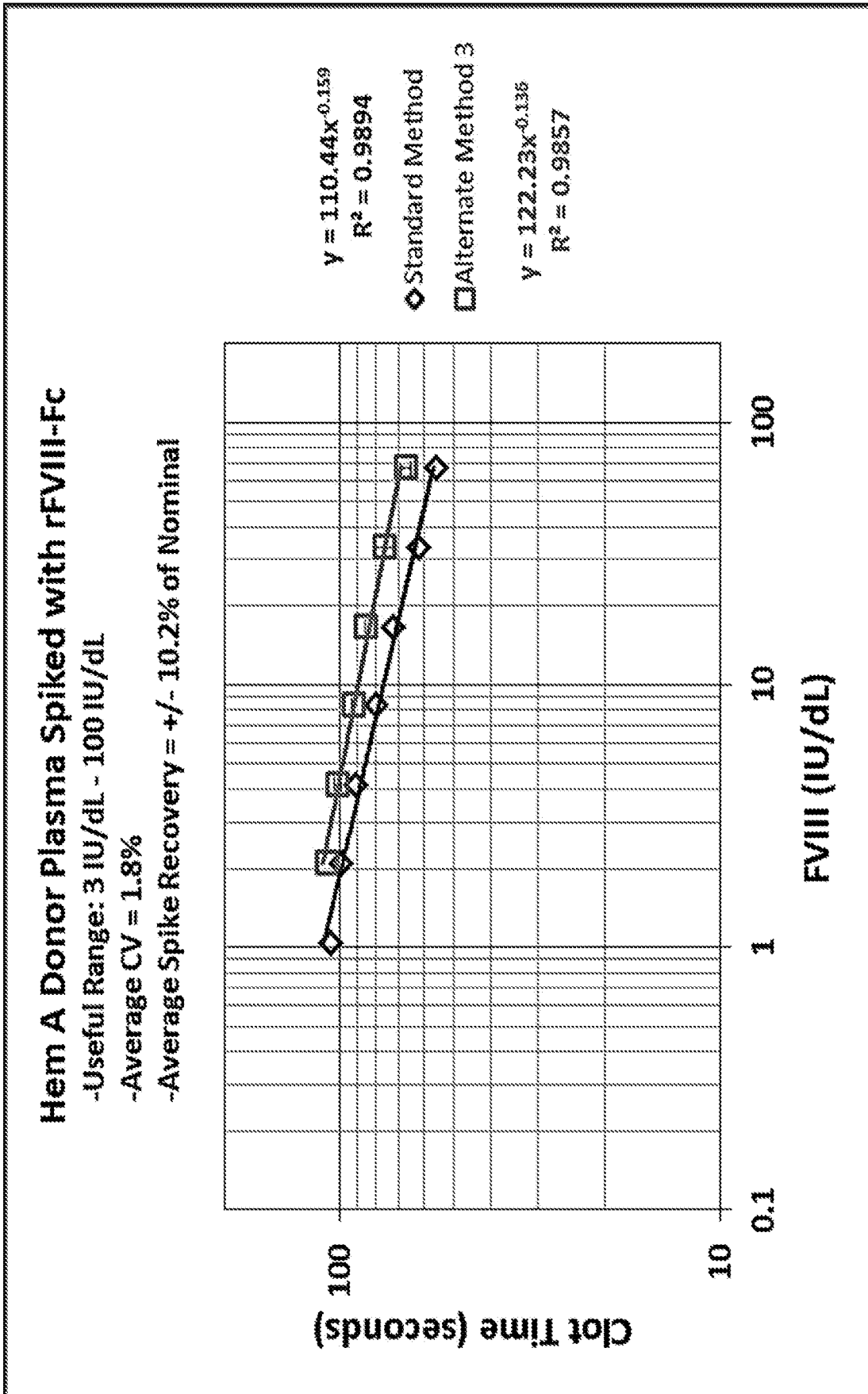


FIG. 6A

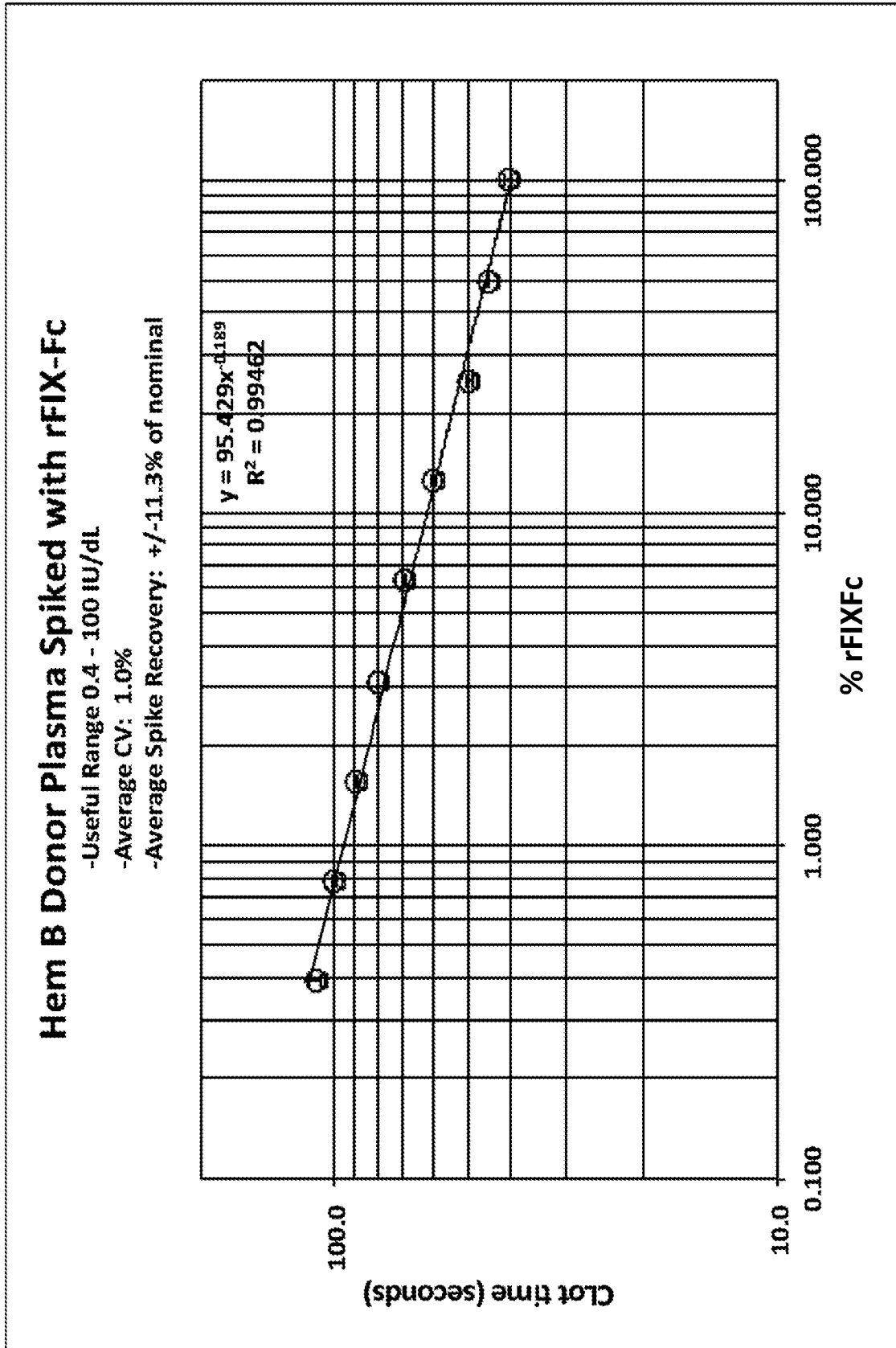


FIG. 6B

9/23

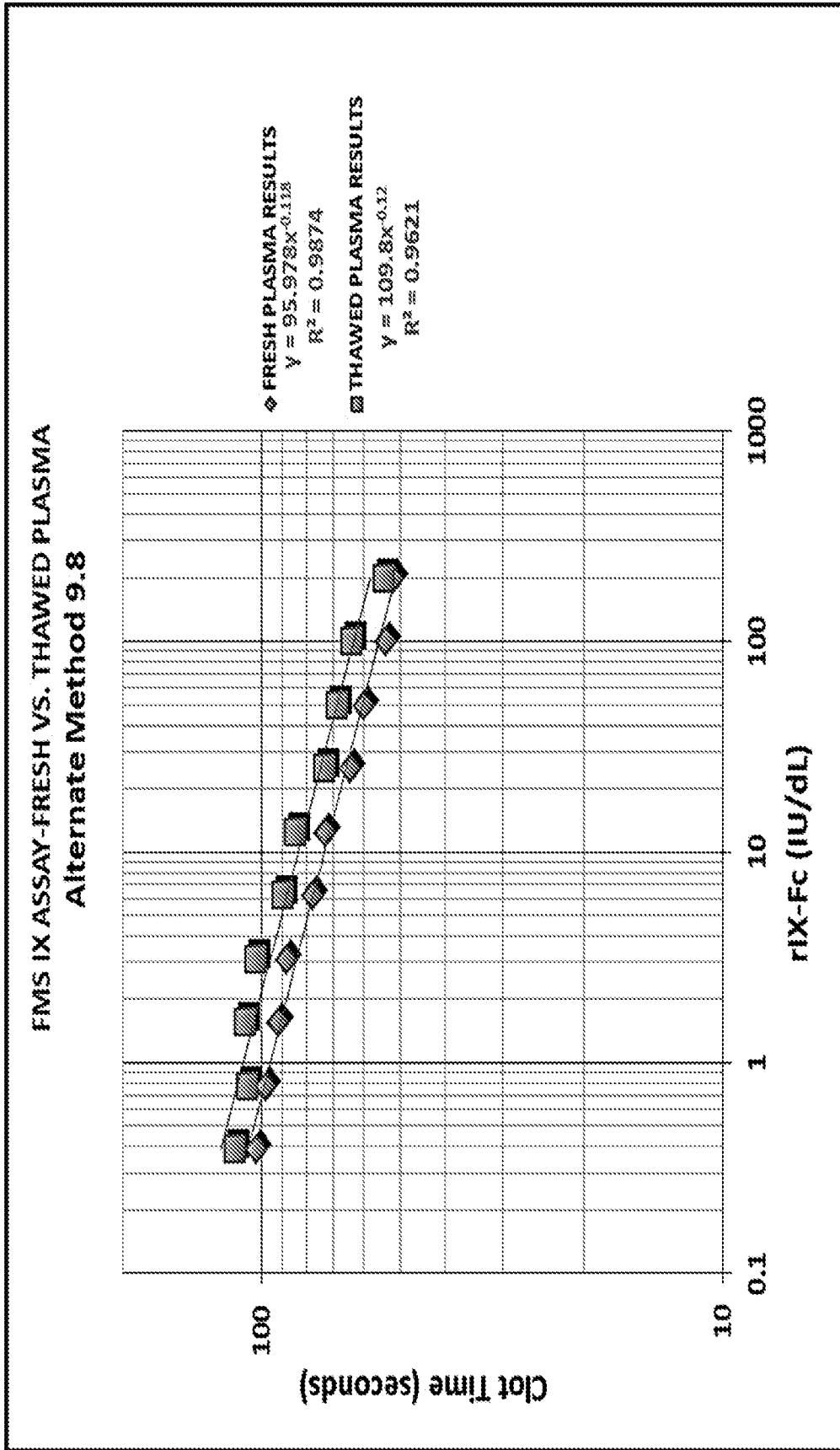


FIG. 7A

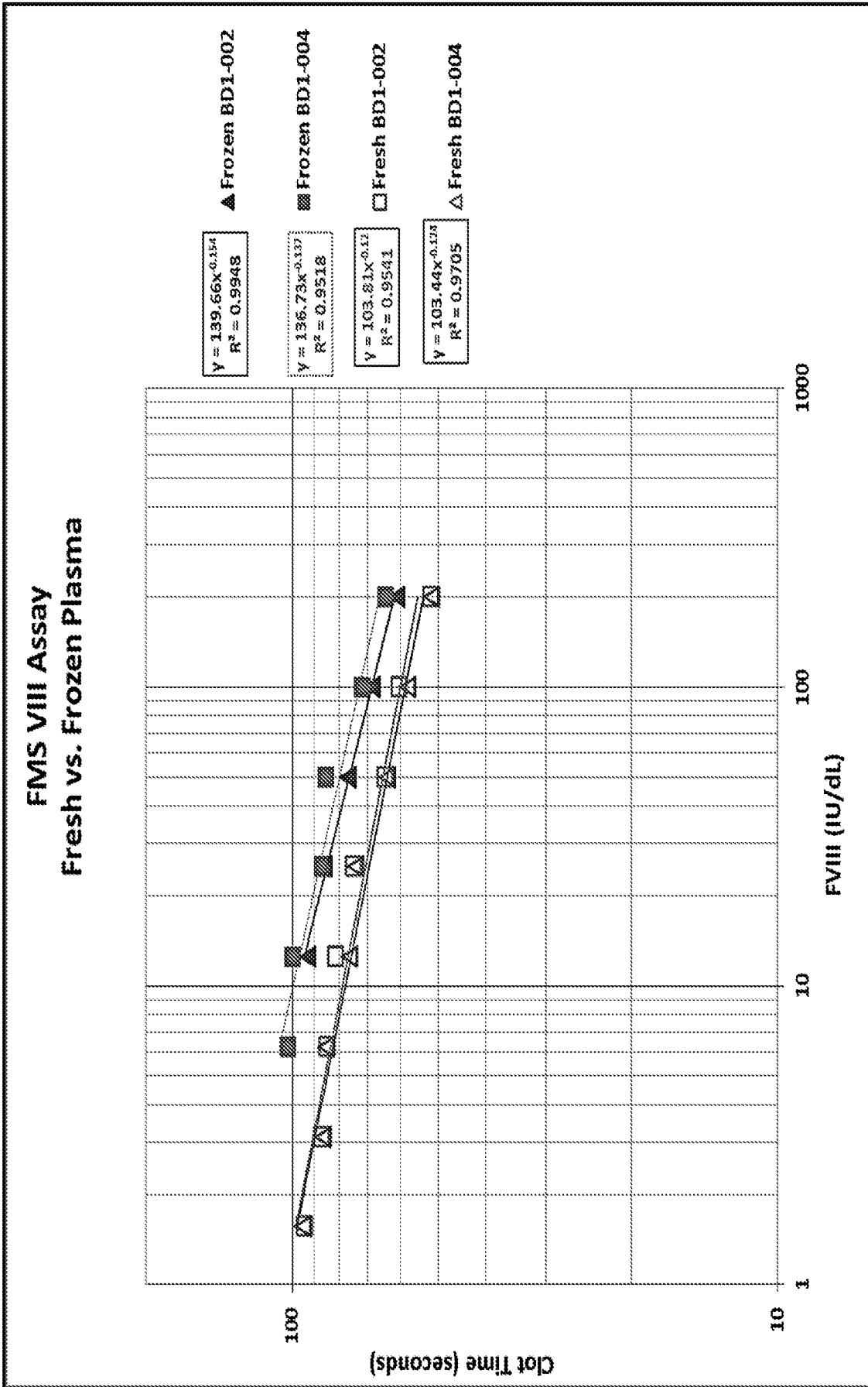


FIG. 7B

11/23

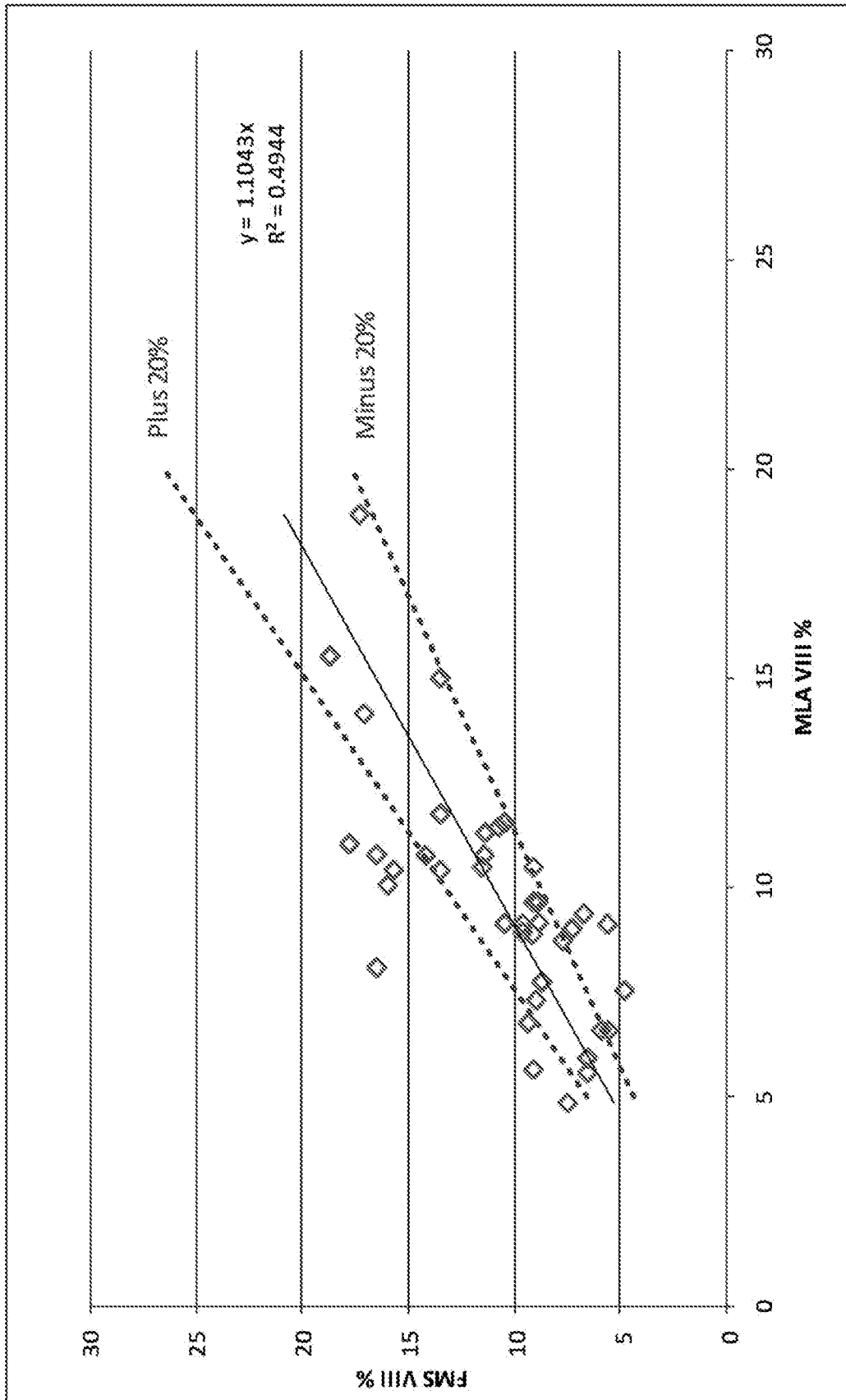


FIG. 8A

12/23

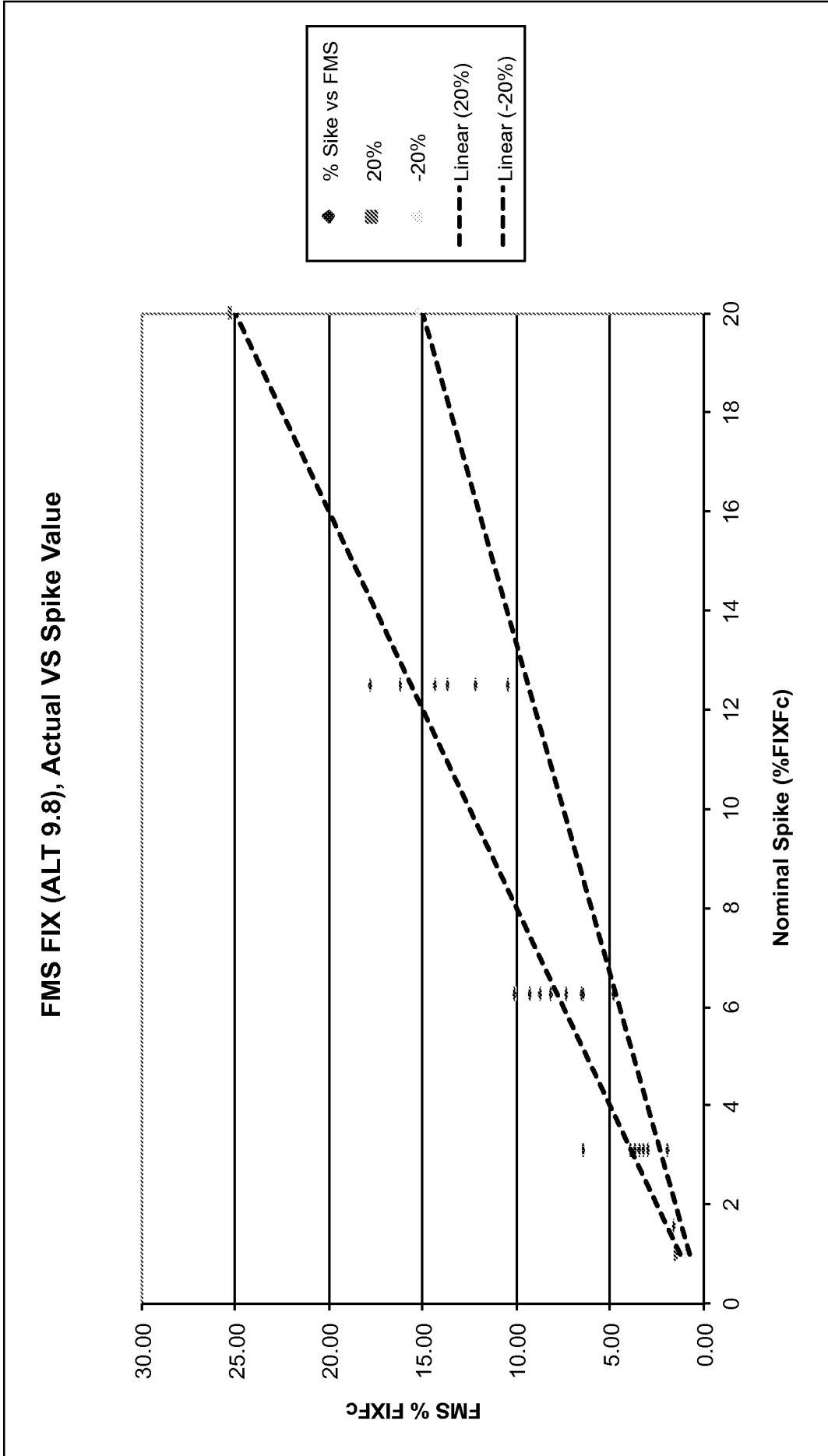


FIG. 8B

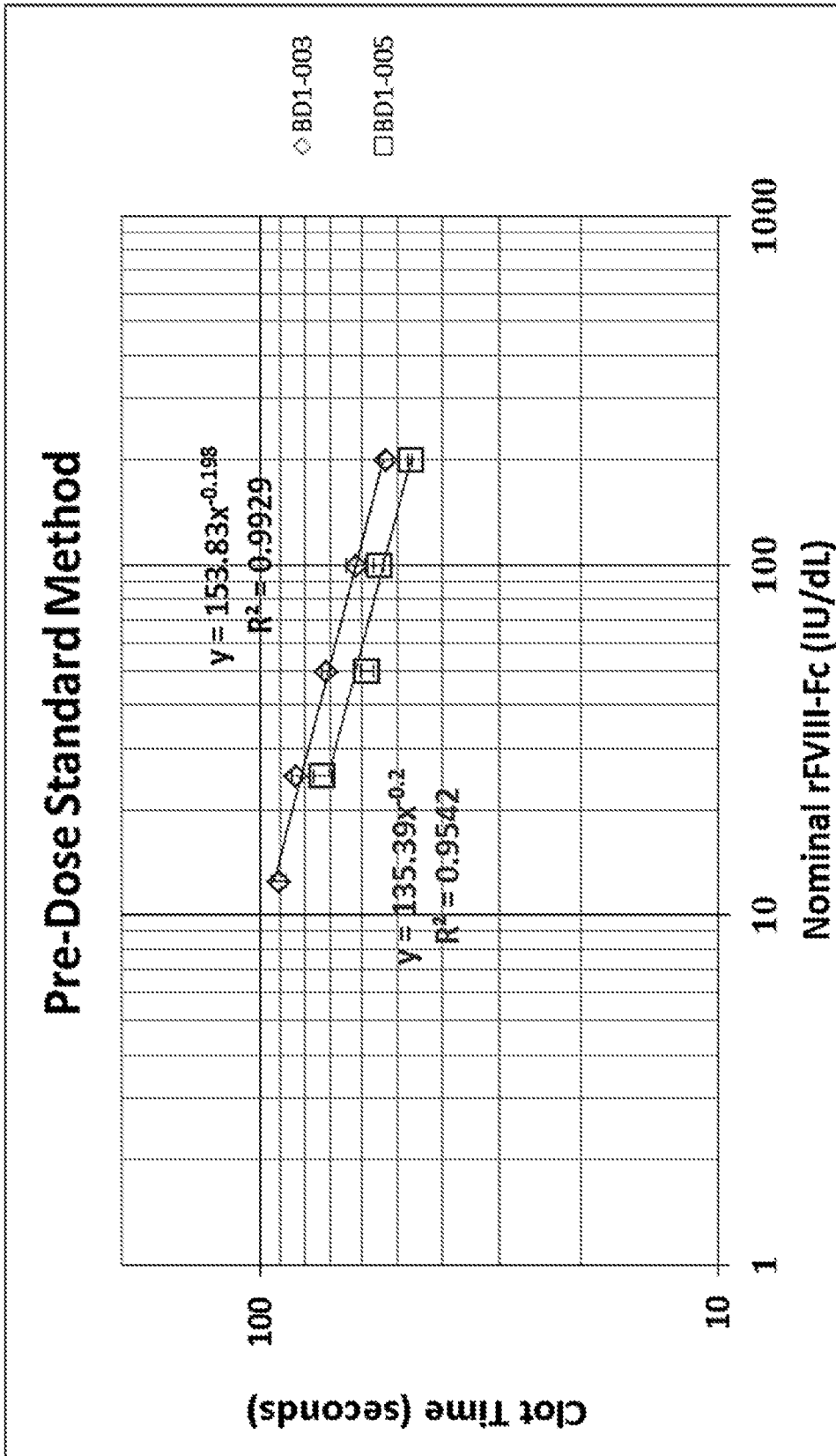


FIG. 9A

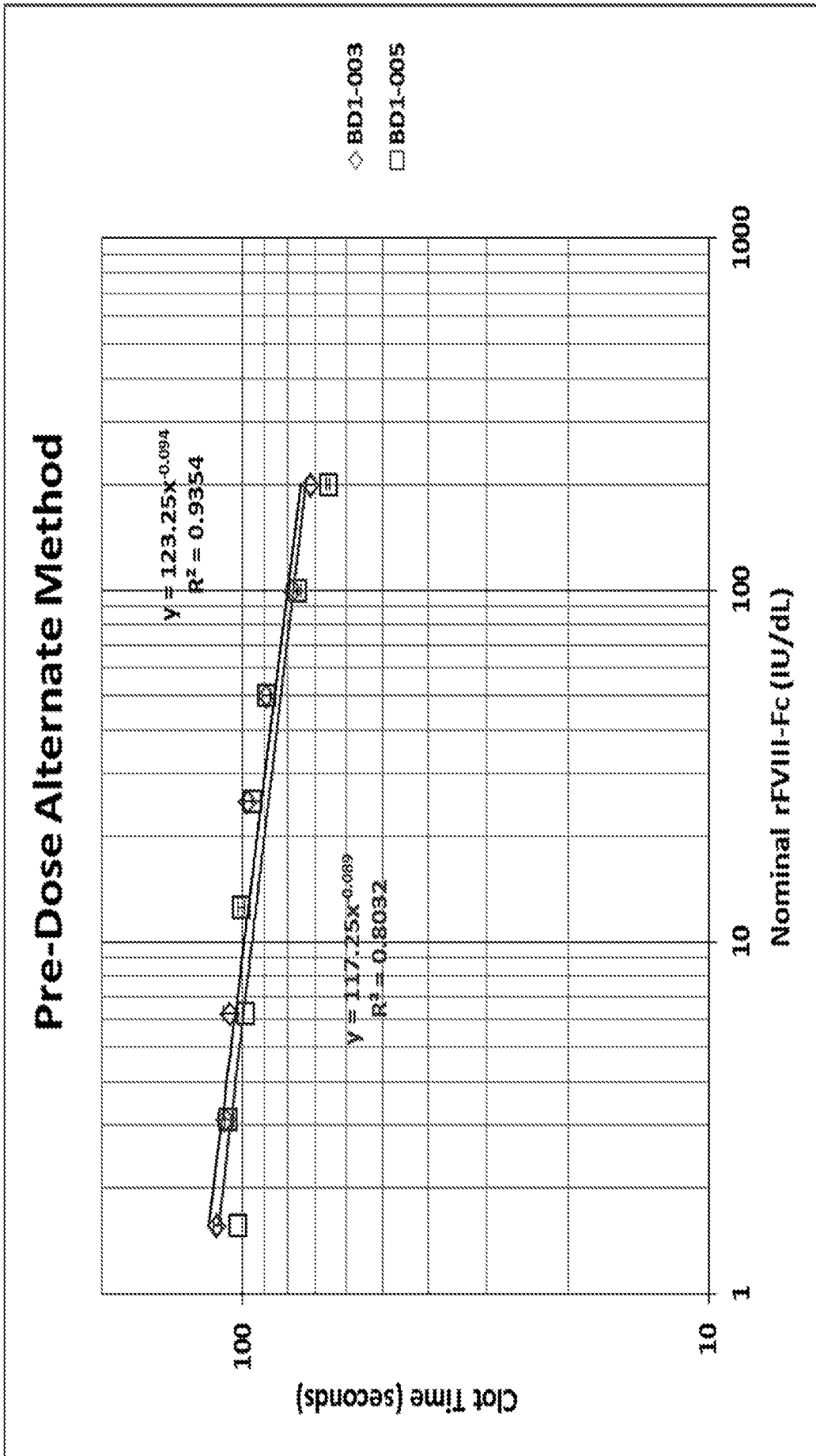


FIG. 9B

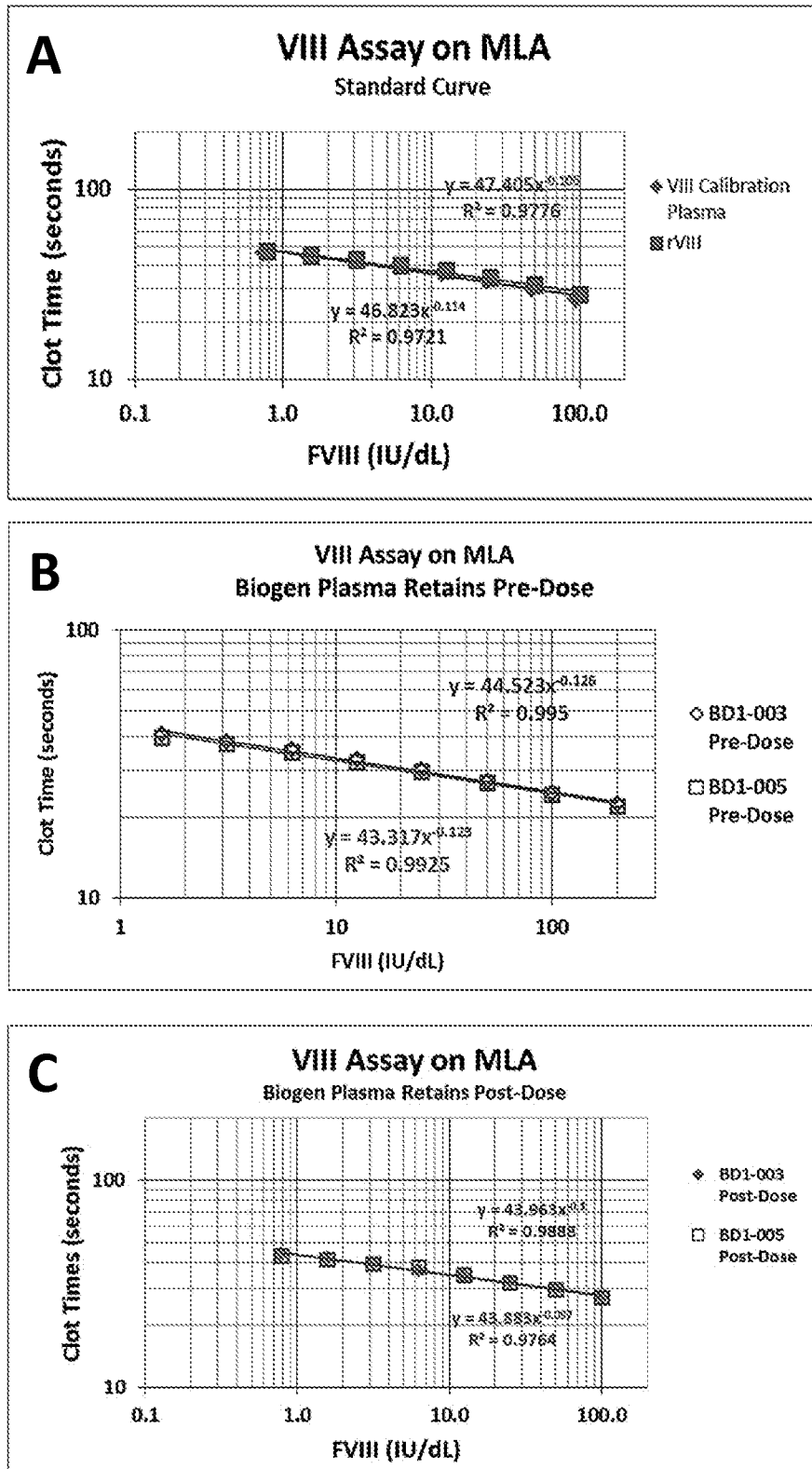


FIG. 10

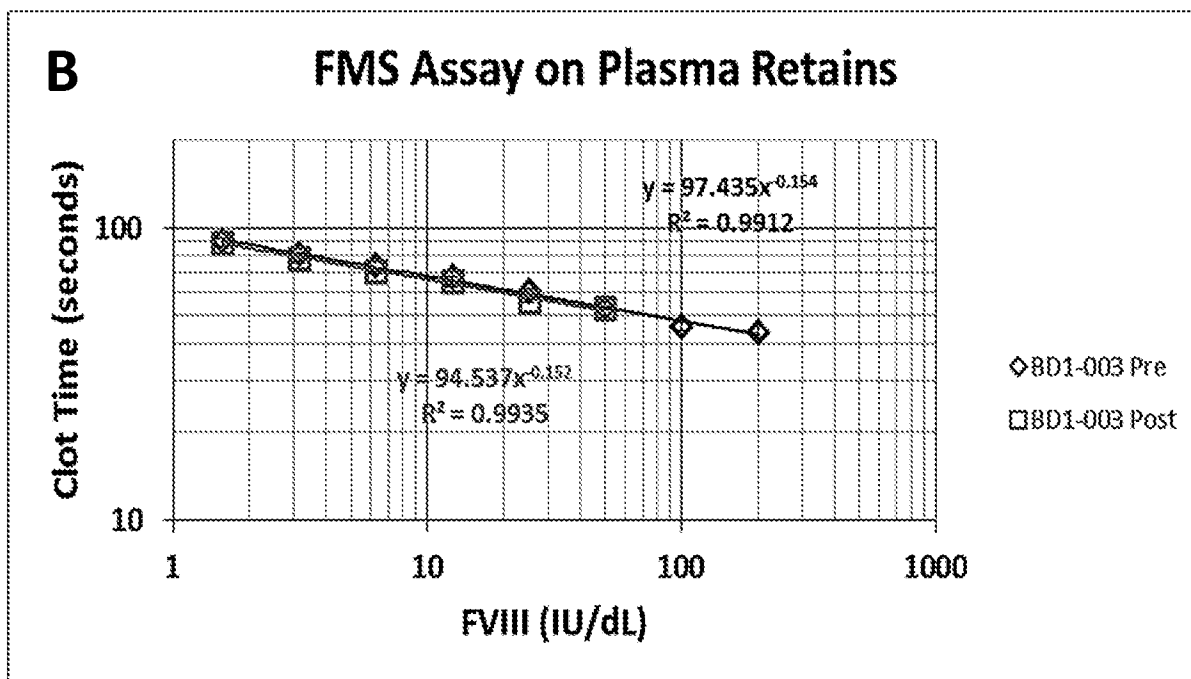
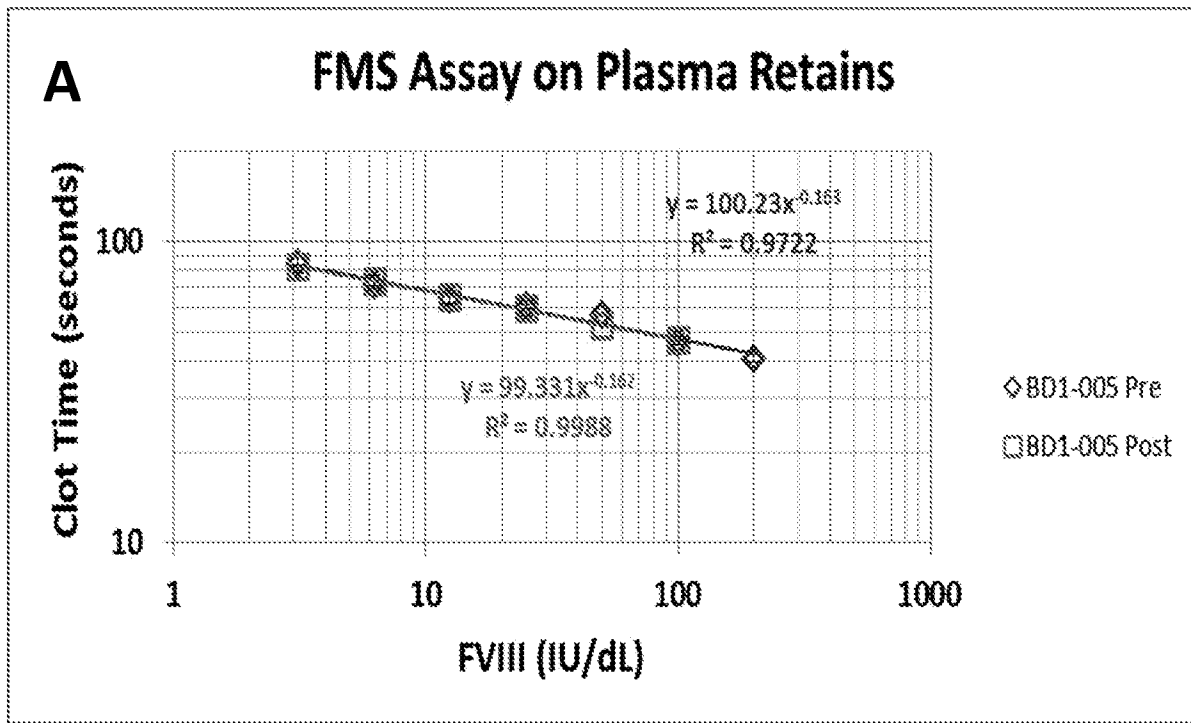


FIG. 11

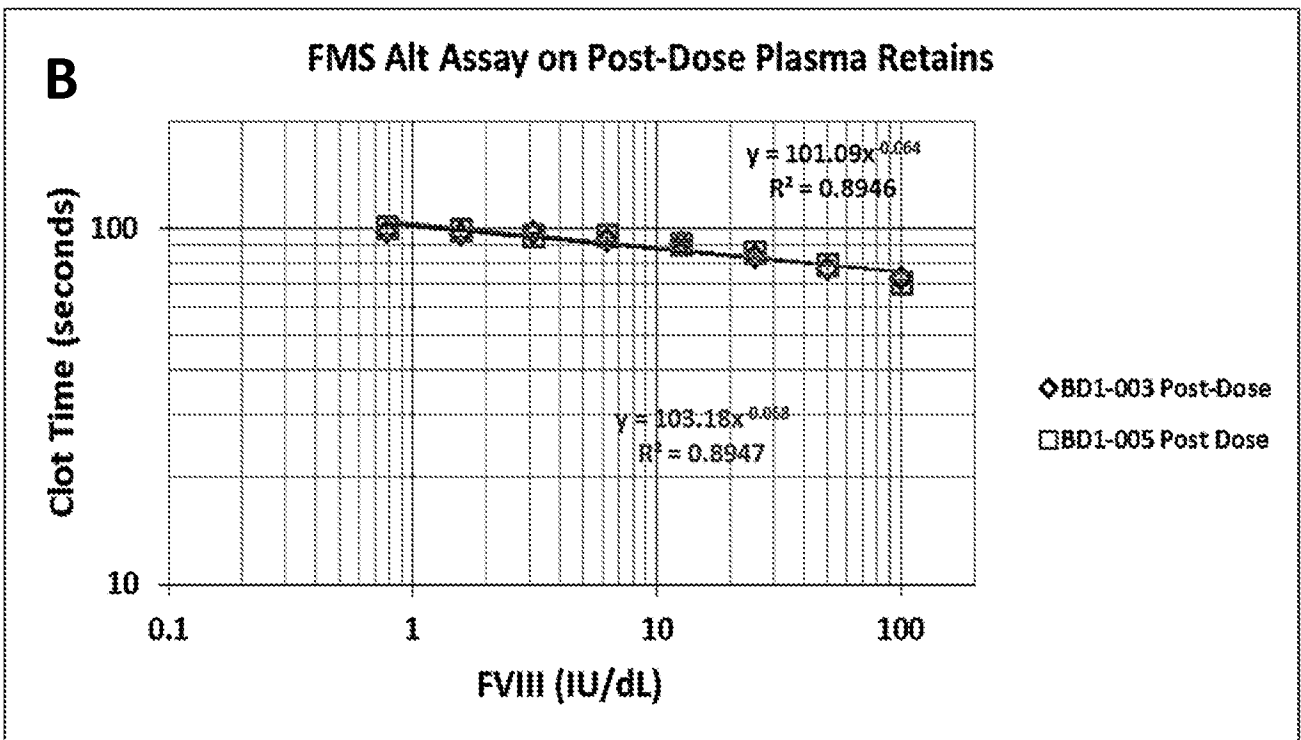
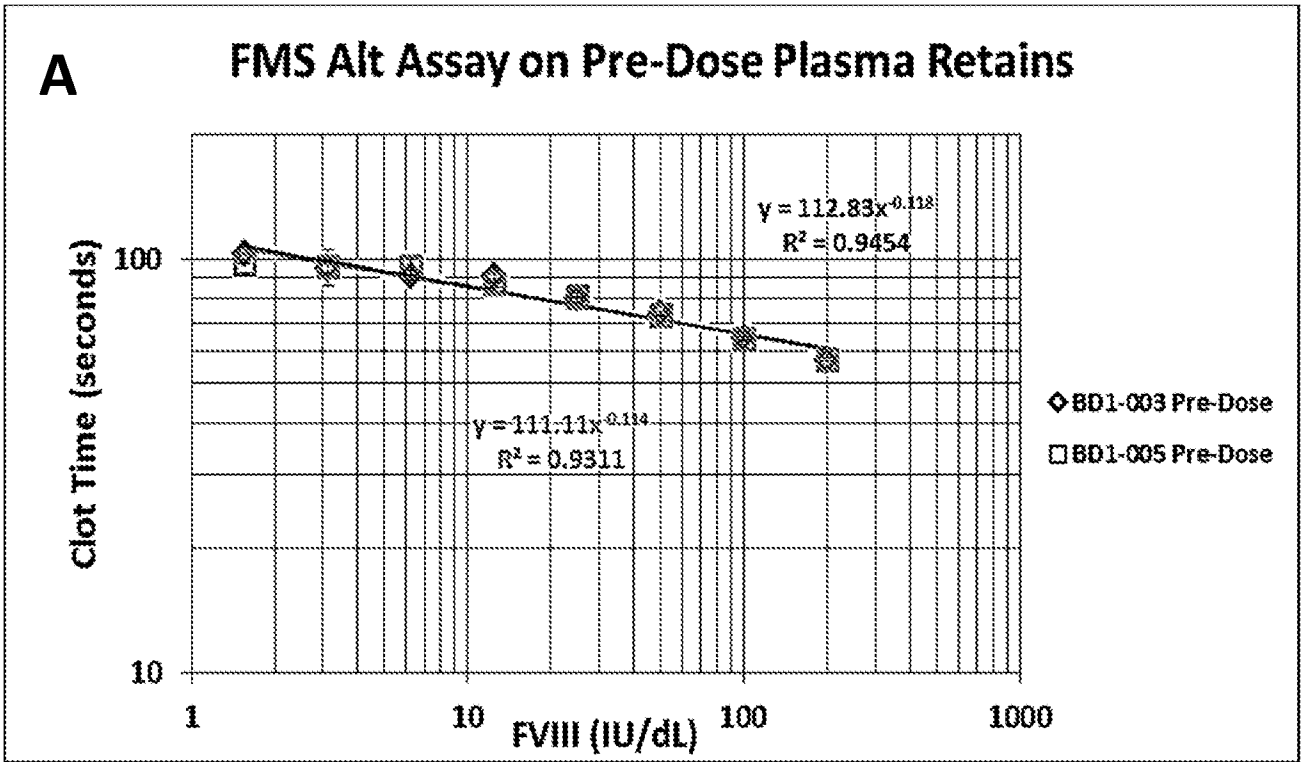


FIG. 12

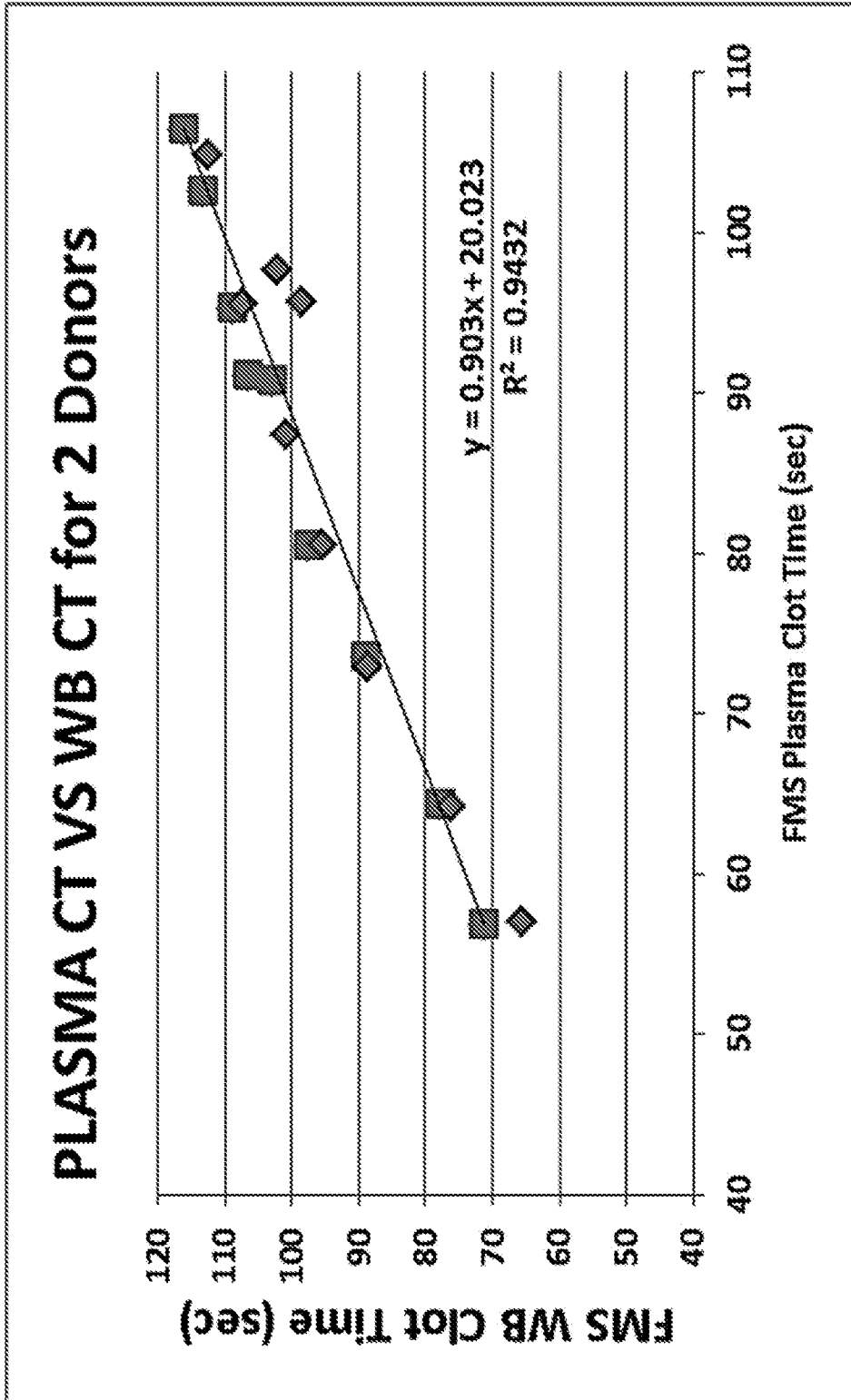


FIG. 13

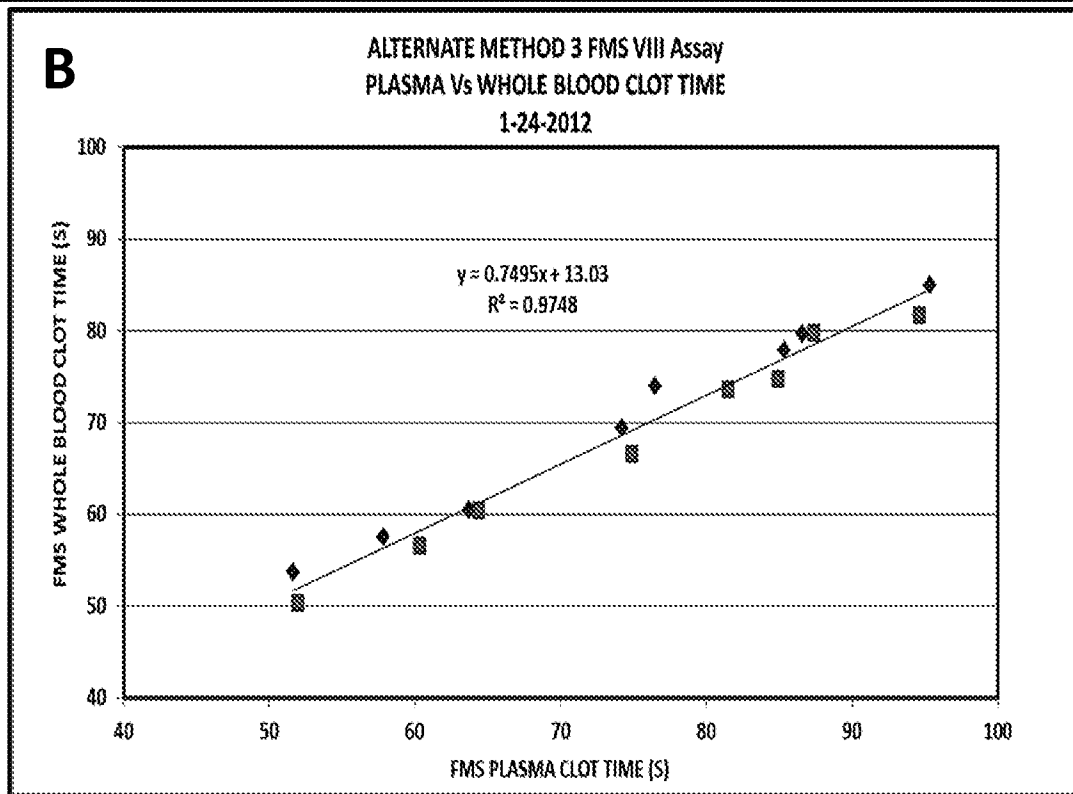
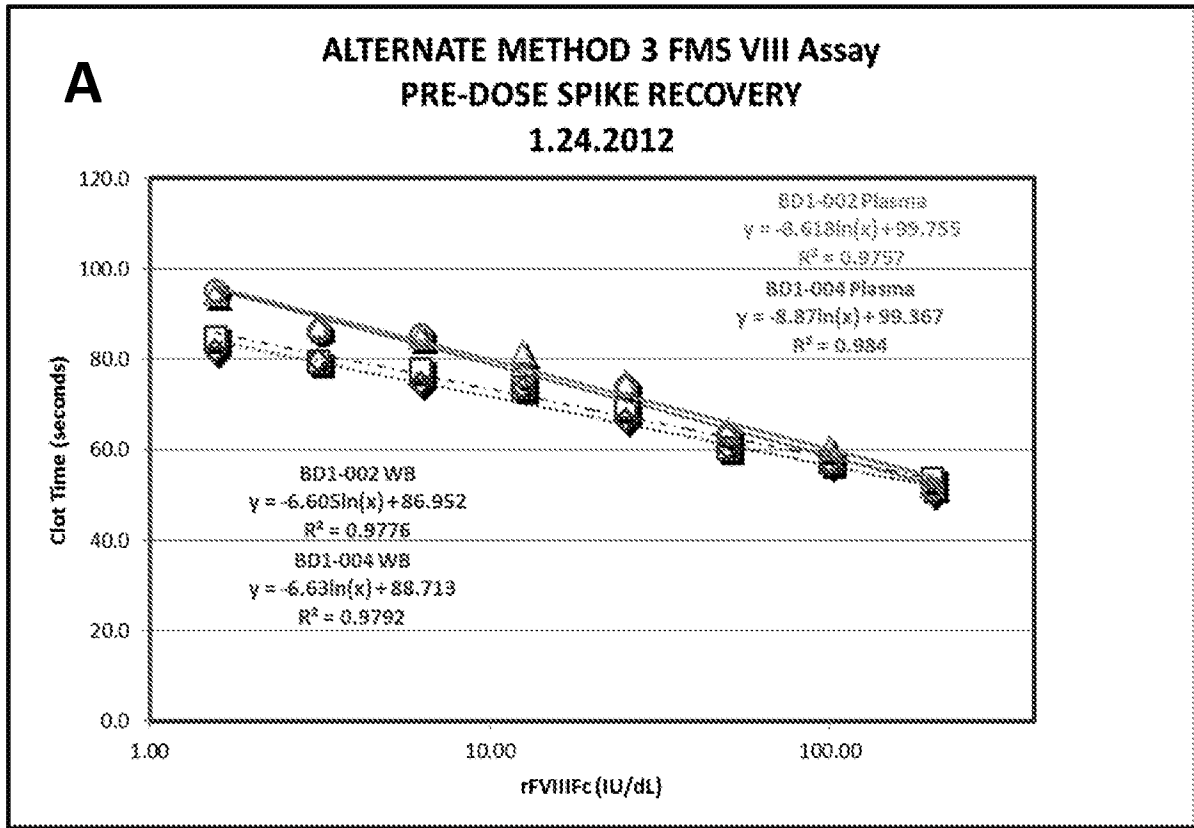


FIG. 14

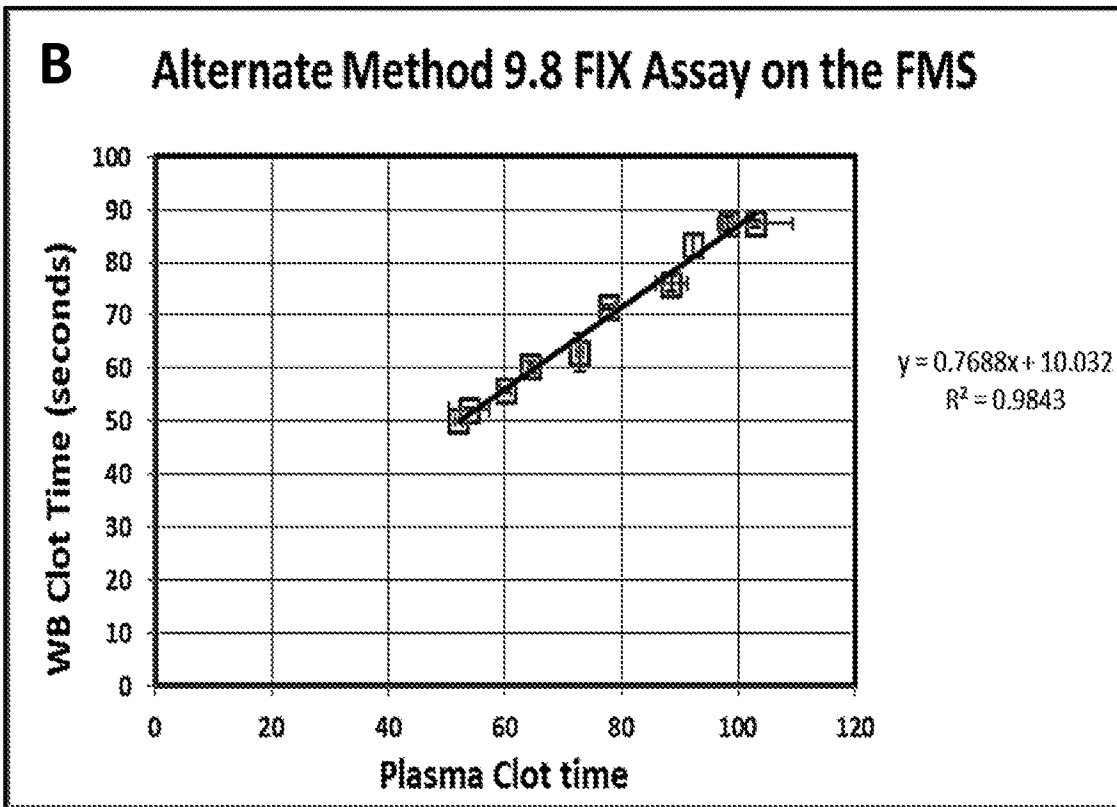
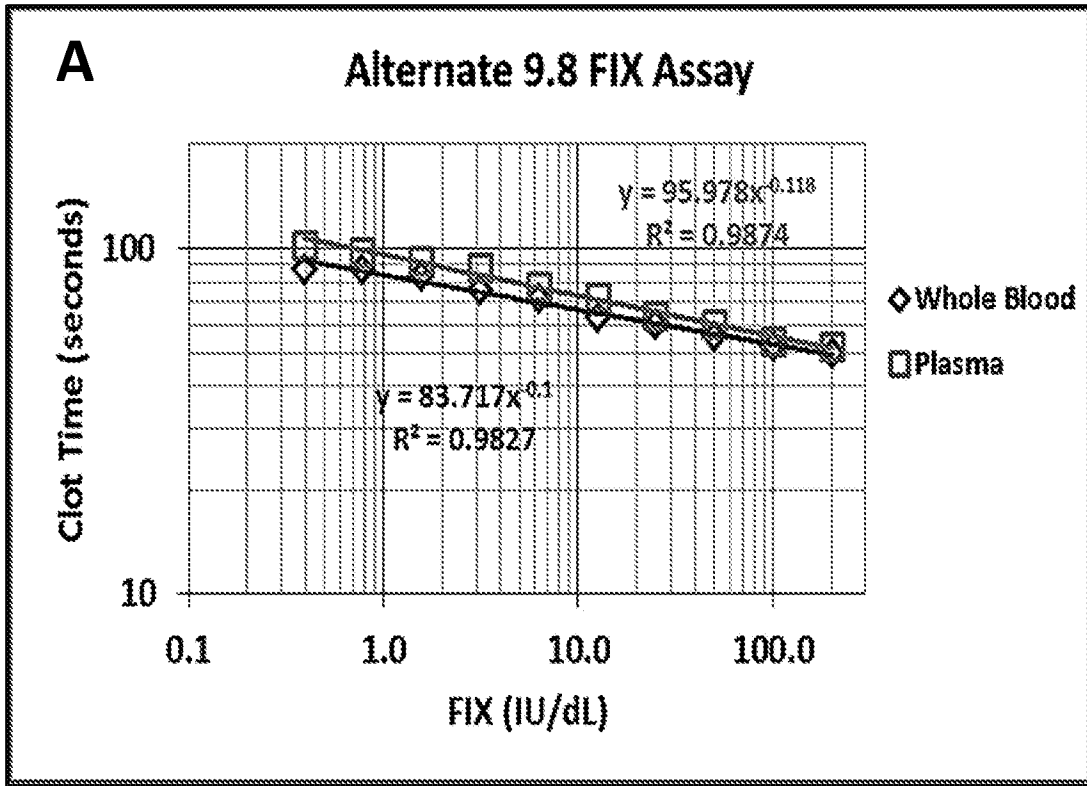


FIG. 15

Meter-Meter Variability 11/10/2011

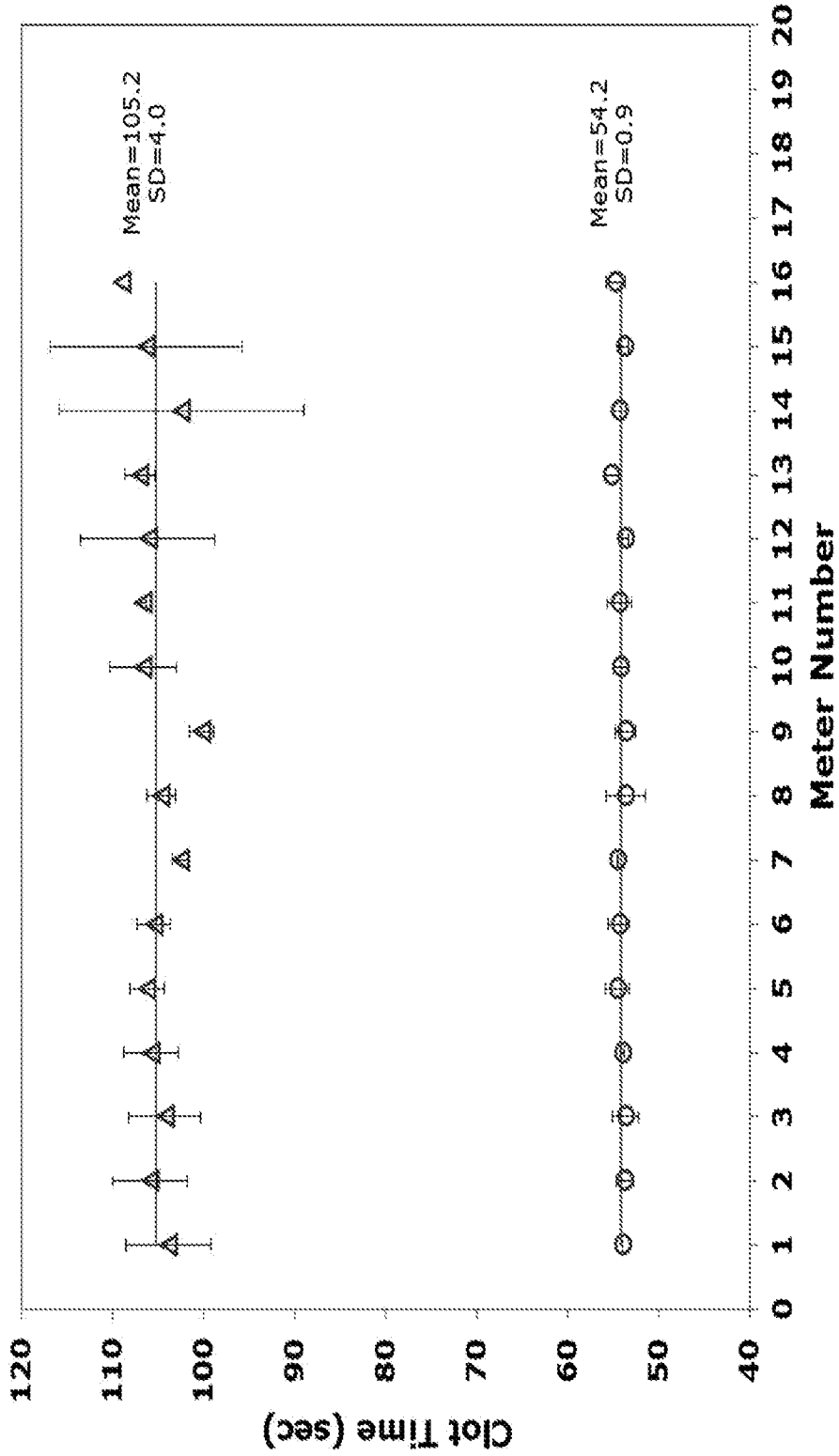


FIG. 16

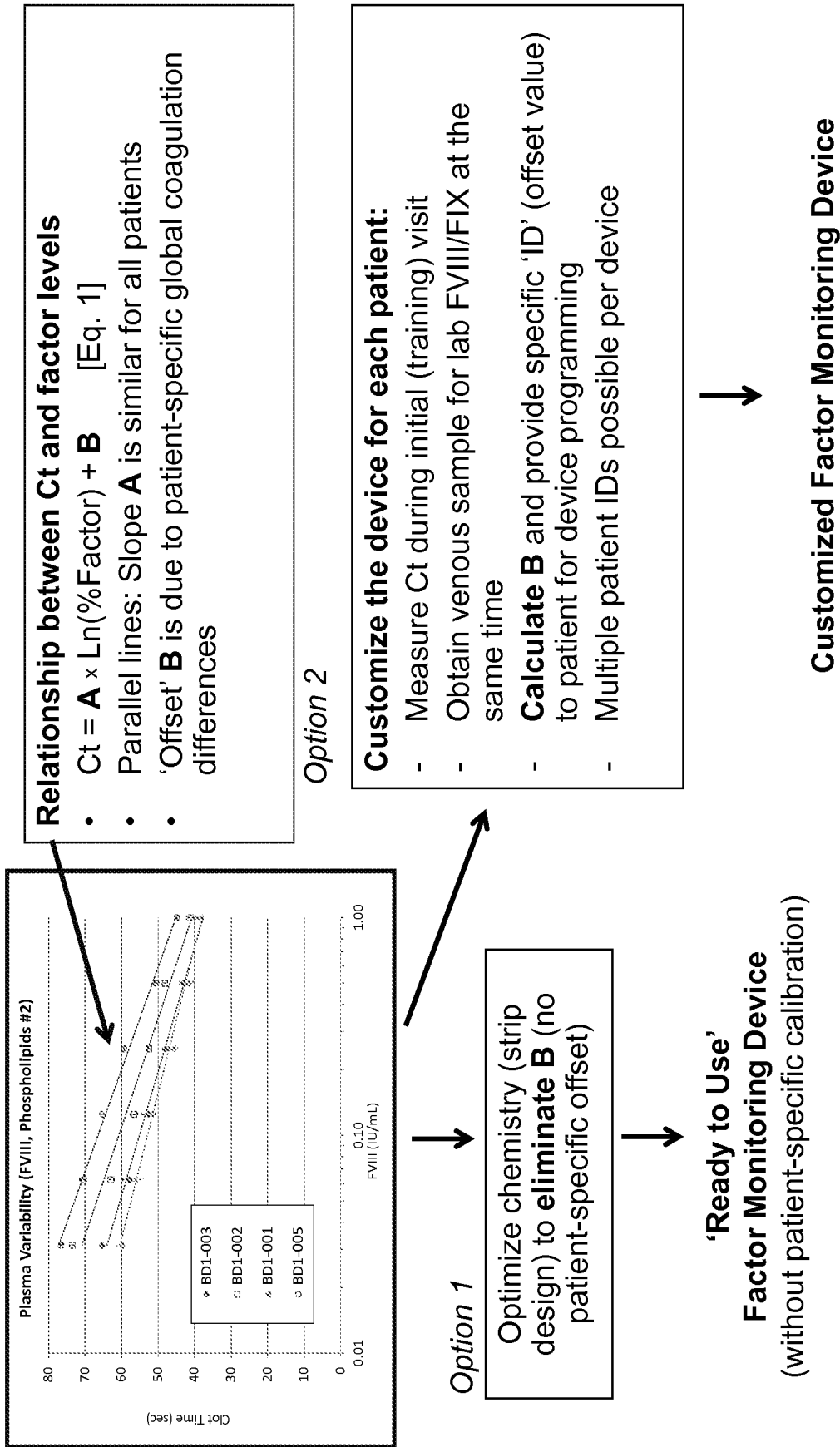
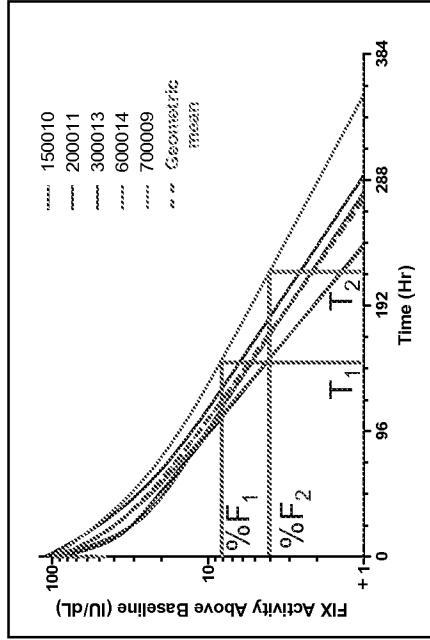


FIG. 17

• **Half-life (HL) in terminal phase of PK:**
 $HL = -0.693 \times (T_2 - T_1) / \ln(\%F_1 / \%F_2)$ [Eq. 2]
 $Ct_1 = A \times \ln(\%F_1) + B$ [from Eq. 1]
 $Ct_2 = A \times \ln(\%F_2) + B$ [from Eq. 1]

• Hence:
 $HL = -0.693(T_2 - T_1) \times A / (Ct_1 - Ct_2)$ [Eq. 3]

Note that the 'offset' (B) becomes irrelevant, i.e. inter-patient differences in global coagulation do not affect terminal half-life



Population Modeling
 (Based on A-LONG and B-LONG results)

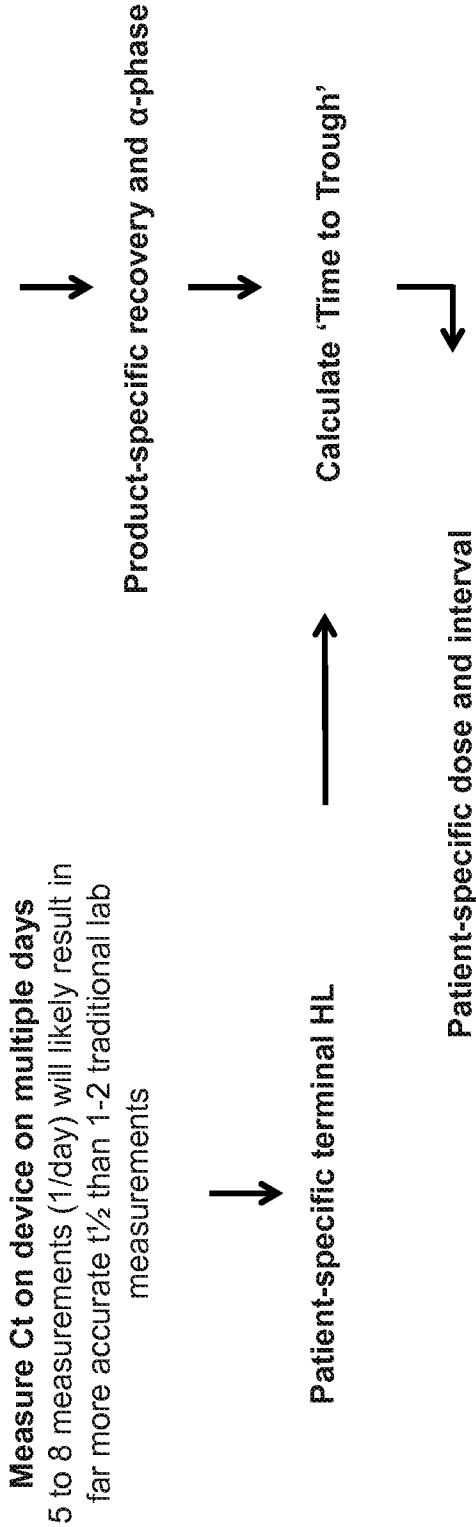


FIG. 18