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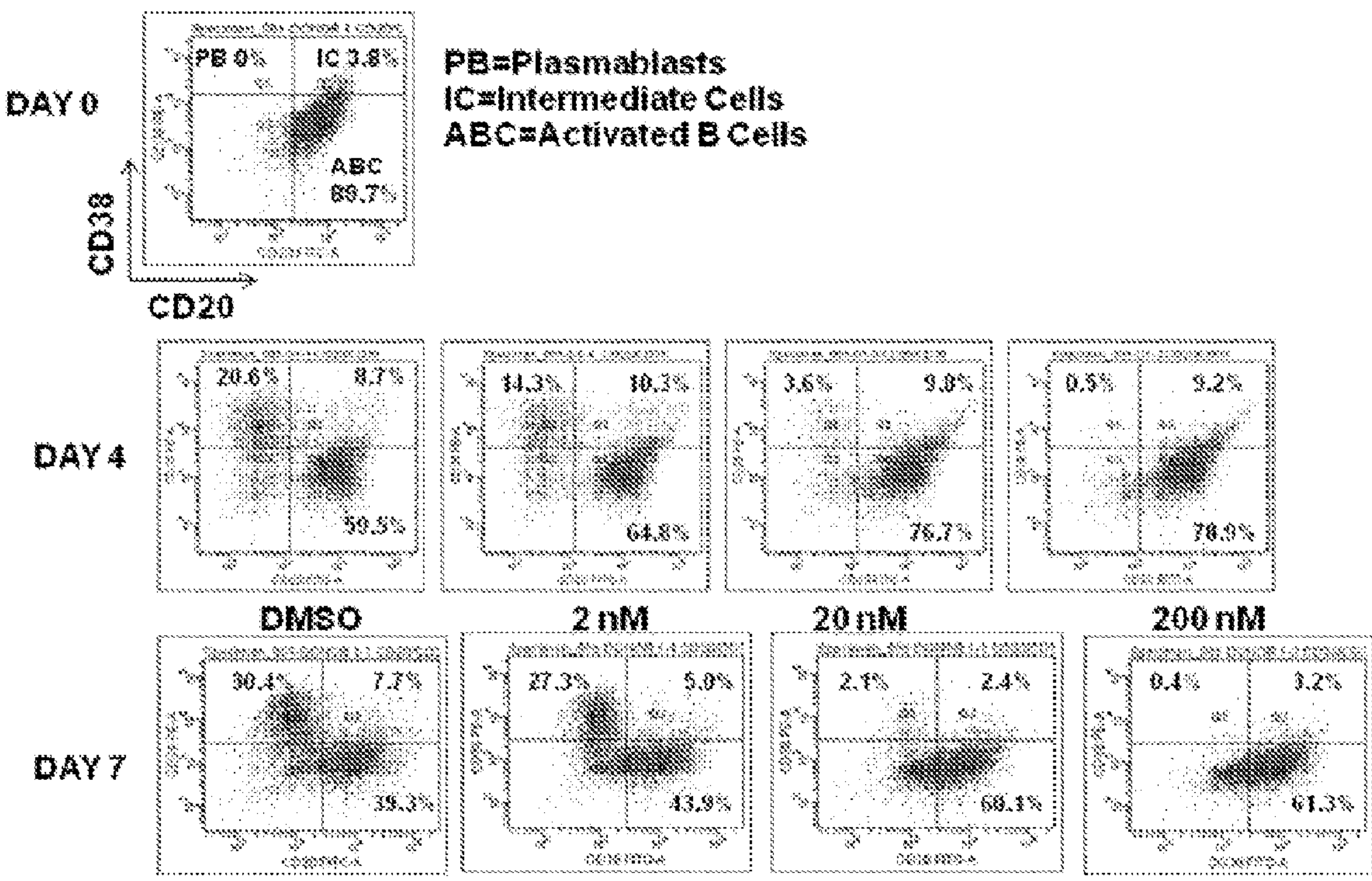
(54) Titre : TRAITEMENT DES MALADIES INFLAMMATOIRES ET ASSOCIEES A L'IMMUNITE
(54) Title: TREATMENT OF IMMUNE-RELATED AND INFLAMMATORY DISEASES

FIG. 1



(57) Abrégé/Abstract:
Provided herein are methods of using compounds and compositions for modulating leukocytic activity, including activity of B cells and/or T cells monocytes, macrophages, and other lymphoid or myeloid-derived cell types, in immune-related diseases or inflammatory diseases. Pharmaceutical compositions and dosing regimens for use in the methods are also provided herein.

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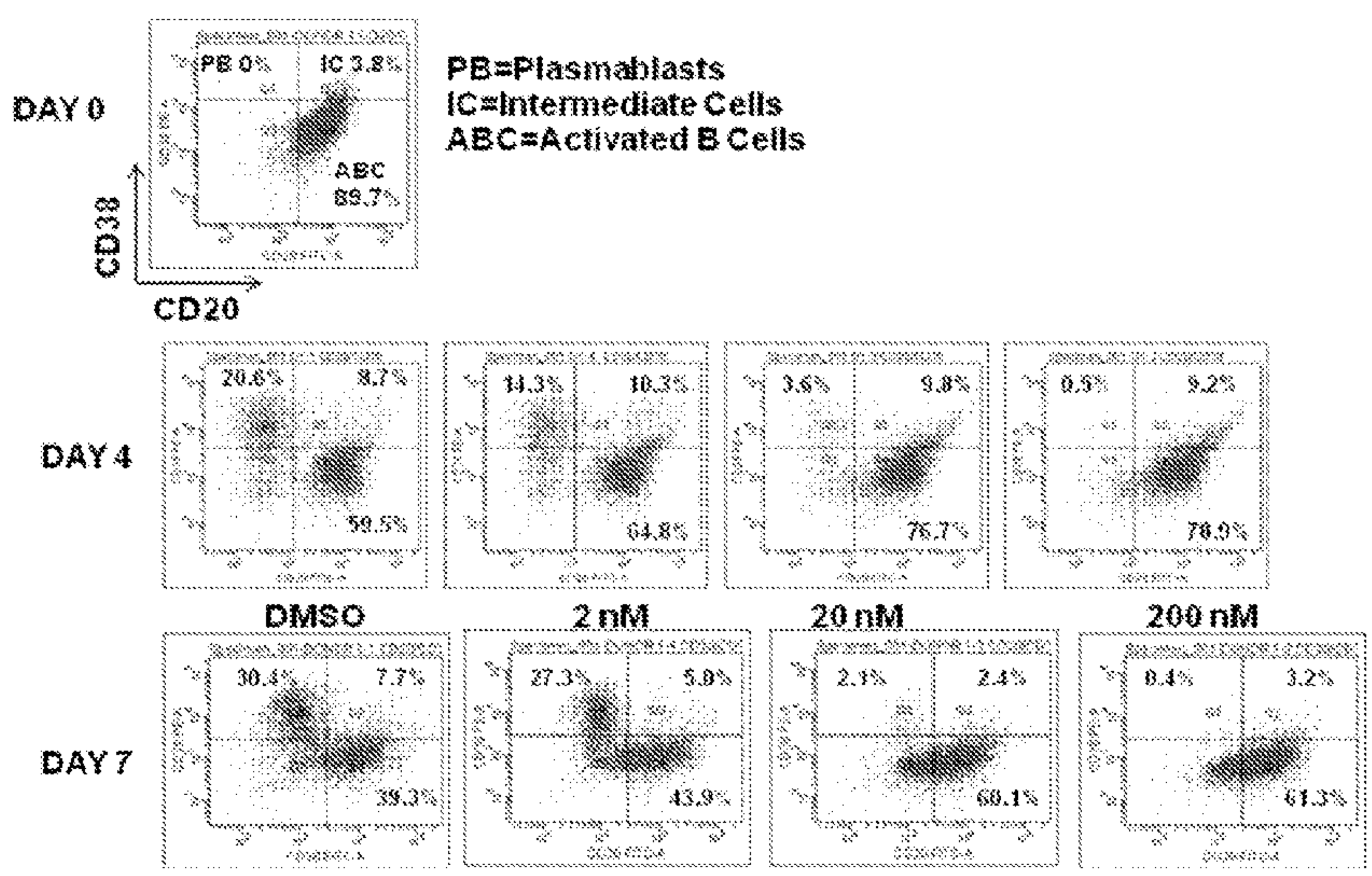
FIG. 1



(57) Abstract: Provided herein are methods of using compounds and compositions for modulating leukocytic activity, including activity of B cells and/or T cells monocytes, macrophages, and other lymphoid or myeloid-derived cell types, in immune-related diseases or inflammatory diseases. Pharmaceutical compositions and dosing regimens for use in the methods are also provided herein.

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TREATMENT OF IMMUNE-RELATED AND INFLAMMATORY DISEASES

1. RELATED APPLICATIONS

[0001] This application claims benefit of U.S. Provisional Patent Application Nos. 61/722,718, filed on November 5, 2012 and 61/681,491, filed on August 9, 2012, which are hereby incorporated by reference herein in their entireties.

2. SEQUENCE LISTING

[0002] The present application is being filed with a Sequence Listing submitted as filename 12827-207-888_SeqListing.txt, of size 6,571 bytes, which was created on August 8, 2012. The Sequence Listing is incorporated herein by reference in its entirety.

3. FIELD

[0003] Provided herein are methods of treating, preventing, and/or managing diseases associated with leukocytic activity, including activity of B cells and/or T cells, monocytes, macrophages, and other lymphoid or myeloid-derived cell types *e.*g., immune-related diseases or inflammatory diseases, comprising administering Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof, including (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione. Pharmaceutical compositions and dosing regimens for such treatment, prevention, and/or management are also provided herein.

4. BACKGROUND

[0004] Inflammatory and immune-related diseases modulated by lymphocytic activity, including activity of B cells and/or T cells, such as lupus, scleroderma, lupus pernio, sarcoidosis, Sjögren syndrome, ANCA-induced vasculitis, anti-phospholipid syndrome and myasthenia gravis, continue to be important medical problems.

[0005] Lupus or lupus erythematosus is a collection of autoimmune disorders that can cause chronic inflammation in various parts of the body, especially the skin, joints, blood, and kidneys. The body's immune system normally makes proteins called antibodies to protect the body against viruses, bacteria, and other foreign materials (i.e., antigens). In an autoimmune disorder such as lupus, the immune system loses its ability to tell the difference between antigens and its own cells and tissues and can make antibodies directed against its own cells and tissues to form immune complexes. These immune complexes can build up in the tissues and cause inflammation, injury to tissues and/or pain. The three most common types of lupus include systemic lupus erythematosus (SLE), cutaneous lupus erythematosus (CLE) and drug-induced lupus. More detailed descriptions of lupus or lupus erythematosus can be found in Wallace, 2000, *The Lupus Book: A Guide for Patients and Their Families*, Oxford University Press, Revised and Expanded Edition, which is incorporated by reference herein in its entirety.

[0006] Scleroderma is a rare disease with a stable incidence of approximately 19 cases per 1 million persons. The exact cause of scleroderma is unknown. Abnormalities involve autoimmunity and alteration of endothelial cell and fibroblast function. Systemic scleroderma usually begins with skin thickening, usually of the fingers, accompanied by Raynaud's phenomenon. Raynaud's disease typically precedes further manifestations of systemic scleroderma. Early in the disease the affected skin may be puffy and soft. The usual location of greatest skin thickening and hardening is the face, hands and fingers. Sclerodactyly is frequently present. Tendon friction rubs are often palpable on exam and can be painful. With more advanced disease, digital ulcers and auto-amputation may occur. Gastrointestinal dismotility is a feature, often manifested by heartburn, or by diarrhea with malabsorption or pseudo-obstruction. New onset hypertension or renal insufficiency are manifestations of the associated vascular injury. Heart failure or arrhythmia are also possible due to cardiac fibrosis. (Hachulla E, Launay D, *Diagnosis and classification of systemic sclerosis*, Clin Rev Allergy Immunol 2010; 40(2):78-83).

[0007] The major manifestations of scleroderma and in particular of systemic sclerosis are inappropriate excessive collagen synthesis and deposition, endothelial dysfunction, spasm, collapse and obliteration by fibrosis. In terms of diagnosis, an important clinical parameter is skin thickening proximal to the metacarpophalangeal joints. Raynaud's phenomenon is a frequent, almost universal component of scleroderma. It is diagnosed by color changes of the skin upon cold exposure. Ischemia and skin thickening are symptoms of Raynaud's disease.

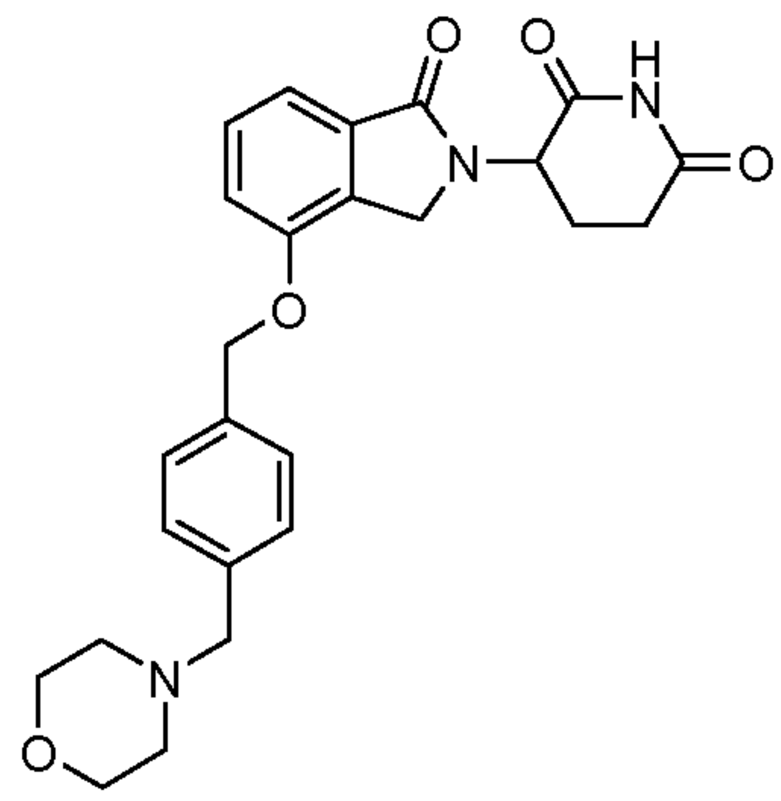
[0008] Sarcoidosis is a disease characterized by granuloma formation, enhanced by lymphocyte and macrophages, usually classified as a T-helper type 1 response. Overproduction of tumor necrosis factor (TNF)-α, IL-8, and IL-18 by alveolar macrophages is thought to be a contributing factor to the underlying lung inflammation. Lupus pernio is a chronic disfiguring skin manifestation of sarcoidosis, primarily affecting the face. Sarcoidosis and associated lupus pernio have limited treatment options such as corticosteroids, which offer only modest benefit (Baughman RP, Judson

MA, Teirstein AS, Moller DR, Lower EE. Thalidomide for chronic sarcoidosis. Chest. 2002 Jul;122(1):227-32).

[0009] There remains a need for prophylactic or therapeutic drugs that can be used to treat or prevent immune-related and inflammatory diseases, including lupus, scleroderma, lupus pernio, sarcoidosis, Sjögren syndrome, ANCA-induced vasculitis, anti-phospholipid syndrome and myasthenia gravis.

5. SUMMARY

[0010] Provided herein are methods of treating, managing, ameliorating and/or preventing diseases, disorders and/or conditions associated with immune-related and inflammatory diseases comprising administering a therapeutically effective amount of a compound of formula I



Compound I,

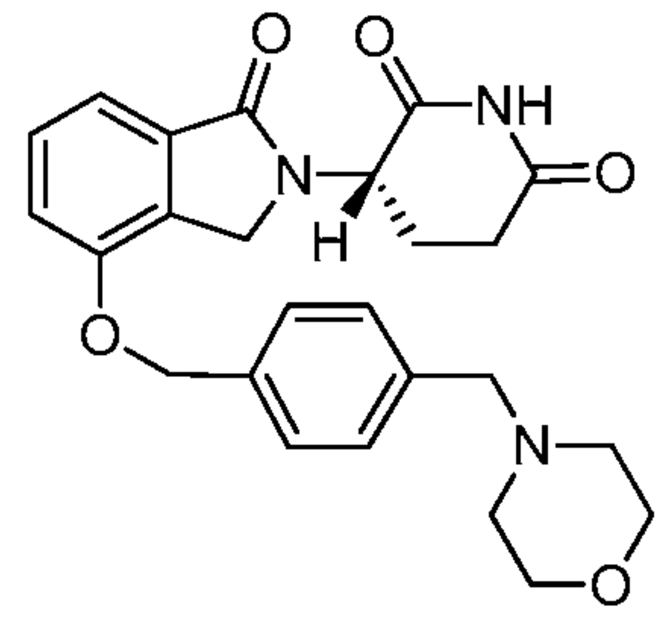
or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof.

[0011] In one embodiment, the compound is 3-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-piperidine-2,6-dione.

[0012] In one embodiment, the compound is a pharmaceutically acceptable salt of 3-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-piperidine-2,6-dione.

[0013] In one embodiment, the compound is 3-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-piperidine-2,6-dione hydrochloride.

[0014] In one embodiment, the compound is (*S*)-3-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-piperidine-2,6-dione, having the following structure:



Compound IA,

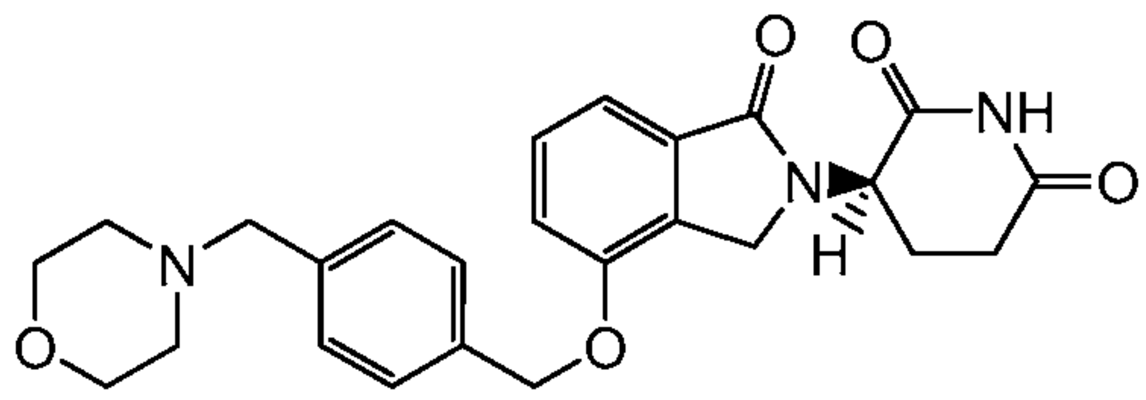
or a pharmaceutically acceptable salt, solvate, hydrate, or tautomer thereof.

[0015] In one embodiment, the compound is (*S*)-3-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-piperidine-2,6-dione.

[0016] In one embodiment, the compound is a pharmaceutically acceptable salt of (*S*)-3-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-piperidine-2,6-dione.

[0017] In one embodiment, the compound is (*S*)-3-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-piperidine-2,6-dione hydrochloride.

[0018] In one embodiment, the compound is (*R*)-3-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-piperidine-2,6-dione, having the following structure:



Compound IB,

or a pharmaceutically acceptable salt, solvate, hydrate, or tautomer thereof.

[0019] In one embodiment, the compound is (*R*)-3-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-piperidine-2,6-dione.

[0020] In one embodiment, the compound is a pharmaceutically acceptable salt of (*R*)-3-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-piperidine-2,6-dione.

[0021] In one embodiment, the compound is (*R*)-3-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-piperidine-2,6-dione hydrochloride.

[0022] In certain embodiments, the disease is selected from lupus, scleroderma, Sjögren syndrome, ANCA-induced vasculitis, anti-phospholipid syndrome and myasthenia gravis.

[0023] In one embodiment, provided herein are methods of modulating, *e.g.*, reducing, leukocytic activity, including activity of B cells and/or T cells, monocytes, macrophages, and other lymphoid or myeloid-derived cell types, comprising contacting B cell and/or T cell with an effective amount of Compound I.

[0024] Also provided herein are pharmaceutical compositions, single unit dosage forms, and kits suitable for use in treating, preventing, ameliorating and/or managing diseases, disorders and/or conditions associated immune-related and inflammatory diseases, which comprise Compound I, optionally in combination with one or more other therapeutic agents.

[0025] In certain embodiments, Compound I is administered in combination with one or more therapeutic agents, *i.e.*, pharmaceutical agents that are modulators of leukocytic activity, including activity of B cells and/or T cells, monocytes, macrophages, and other lymphoid or myeloid-derived cell types. The combinations encompass simultaneous as well as sequential administration.

6. BRIEF DESCRIPTION OF DRAWINGS

[0026] FIG. 1 depicts effect of (S)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on plasmablast and activated B cell differentiation.

[0027] FIG. 2 depicts effect of (S)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on cell viability during plasmablast differentiation.

[0028] FIG. 3 depicts effect of (S)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on B and plasma cell transcription factor expression.

[0029] FIG. 4 depicts effect of (S)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on IgG production in plasmablast cultures.

[0030] FIGs. 5A and 5B depict effect of (S)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on B and plasma cell transcription factor expression.

[0031] FIG. 6 depicts effect of (S)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on IgG production in B cell cultures on days 4, 7 and 10.

[0032] FIG. 7 depicts effect of (S)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione, alone and in combination with prednisolone, on IgG production by in vitro-differentiated plasma blasts/plasma cells.

[0033] FIG. 8 depicts effect of (S)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on CD20/CD38 expression during B cell differentiation at day 7.

[0034] FIG. 9 depicts effect of (S)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on cell viability during plasmablast differentiation.

[0035] FIG. 10 depicts effect of (S)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on B cell differentiation and function in SLE patient PBMC in vitro.

[0036] FIGs. 11A and 11B depict effect of (S)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on on IgG and IgM production,respectively, in B cell cultures on day 7.

[0037] FIG. 12 depicts effect of (S)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on differentiation of CD19+ B cell into plasma blasts/plasma cells.

[0038] FIG. 13 depicts effect of (S)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on large size cell population (gate p2) in normal B cell differentiation assay.

[0039] FIG. 14 depicts effect of (S)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on plasma cell transcription factors in B cell differentiation culture.

[0040] FIGs. 15A–15E depict effect of (S)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione (20 nM) on plasma cell transcription factor expression in day 7 cultured B cells.

[0041] FIG. 16 depicts effect of (S)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on transcription factors expression in CD38+ plasmablast/plasma cells from differentiating SLE patient PBMC.

[0042] FIG. 17 depicts effect of (S)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione (represented as compound I in the figure) on CD44 MFI at day 7 B cell differentiation culture.

[0043] FIG. 18 depicts effect of (S)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on $CD20^{high}/CD44^{high}$ cells at day 7 normal B cell differentiation assay.

[0044] FIG. 19 depicts effect of (S)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione (represented as compound I in the figure) on CD83+ cells and expression at day 4 and day7 B cell differentiation culture.

[0045] FIG. 20 depicts effect of (S)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione (represented as compound I in the figure) on Ig J chain expression during B cell differentiation culture.

[0046] FIG. 21 illustrates the effect of 3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on production of certain cytokines and chemokines in anti-CD3-stimulated human T cells, expressed as absolute amount produced.

[0047] FIG. 22 illustrates the effect of 3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on production of certain cytokines and chemokines in anti-CD3-stimulated human T cells, expressed as percentage of control.

[0048] FIG. 23 illustrates the effect of (*R*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on production of certain cytokines and chemokines in anti-CD3-stimulated human T cells, expressed as absolute amount produced.

[0049] FIG. 24 illustrates the effect of (*R*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on production of certain cytokines and chemokines in anti-CD3- stimulated human T cells, expressed as percentage of control.

[0050] FIG. 25 illustrates the effect of (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on production of certain cytokines and chemokines in anti-CD3- stimulated human T cells, expressed as absolute amount produced.

[0051] FIG. 26 illustrates the effect of (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on production of certain cytokines and chemokines in anti-CD3-stimulated human T cells, expressed as percentage of control.

[0052] FIG. 27 illustrates inhibition of production of certain cytokines and chemokines in lipopolysaccharide-stimulated peripheral blood mononuclear cells by 3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

[0053] FIG. 28 illustrates enhancement of on production of certain cytokines and chemokines in lipopolysaccharide-stimulated peripheral blood mononuclear cells by 3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

[0054] FIG. 29 illustrates inhibition of on production of certain cytokines and chemokines in lipopolysaccharide-stimulated peripheral blood mononuclear cells by (*R*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

[0055] FIG. 30 illustrates enhancement of on production of certain cytokines and chemokines in lipopolysaccharide-stimulated peripheral blood mononuclear cells by (*R*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

[0056] FIG. 31 illustrates inhibition of on production of certain cytokines and chemokines in lipopolysaccharide-stimulated peripheral blood mononuclear cells by (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

[0057] FIG. 32 illustrates enhancement of on production of certain cytokines and chemokines in lipopolysaccharide-stimulated peripheral blood mononuclear cells by (S)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

[0058] FIG. 33 illustrates enhancement of NK cell IFN-gamma production in response to immobilized IgG and IL-2, expressed as absolute amount produced, by 3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

[0059] FIG. 34 illustrates enhancement of NK cell IFN-gamma production in response to immobilized IgG and IL-2, expressed as absolute amount produced, by (*R*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

[0060] FIG. 35 illustrates enhancement of NK cell IFN-gamma production in response to immobilized IgG and IL-2, expressed as absolute amount produced, by (*S*)-

3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

[0061] FIG. 36 illustrates enhancement of NK cell IFN-gamma production in response to immobilized IgG and IL-2, expressed as percentage of amount of IFN-gamma produced in the presence of 1 μm pomalidomide, by 3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

[0062] FIG. 37 illustrates enhancement of NK cell IFN-Gamma Production in Response to Immobilized IgG and IL-2, expressed as percentage of amount of IFN-gamma produced in the presence of 1 μm pomalidomide, by (*R*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

[0063] FIG. 38 illustrates enhancement of NK cell IFN-Gamma Production in Response to Immobilized IgG and IL-2, expressed as percentage of amount of IFN-gamma produced in the presence of 1 μm pomalidomide, by (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

[0064] FIG. 39 depicts effect of compounds provided herein on growth factor-induced human umbilical vascular endothelial cell proliferation.

[0065] FIG. 40 depicts effect of compounds provided herein on growth factor-induced human umbilical vascular endothelial cell tube formation.

[0066] FIG. 41 depicts effect of compounds provided herein on growth factor-induced human umbilical vascular endothelial cell invasion.

[0067] FIG. 42 depicts effect of (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on dermal thickness of lesional skin in the bleomycin dermal fibrosis mouse model (prevention of inflammation driven fibrosis).

[0068] FIG. 43 depicts hematoxylin and eosin stained skin section photomicrographs showing dermal thickness of lesional skin in the bleomycin dermal fibrosis mouse model (prevention of inflammation driven fibrosis).

[0069] FIG. 44 depicts effect of (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on the numbers of alpha-SMA + myofibroblasts in lesional skin in the bleomycin dermal fibrosis mouse model (prevention of inflammation driven fibrosis).

[0070] FIG. 45 depicts effect of compounds tested on dermal thickness of lesional skin in the bleomycin dermal fibrosis mouse model (regression of established fibrosis).

[0071] FIG. 46 depicts hematoxylin and eosin stained skin section photomicrographs showing dermal thickness of lesional skin in the bleomycin dermal fibrosis mouse model (regression of established fibrosis).

[0072] FIG. 47 depicts reduction in the numbers of alpha-SMA + myofibroblasts in lesional skin in the bleomycin dermal fibrosis mouse model (regression of established fibrosis).

[0073] FIG. 48A depicts reduction of dermal thickness by (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione in TSK-1 mice.

[0074] FIG. 48B depicts reduction of relative hydroxyproline contents by (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione in TSK-1 mice.

[0075] FIG. 49A depicts modulation of CTGF by (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

[0076] FIG. 49B depicts modulation of PAI-1 by (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

[0077] FIG. 49C depicts modulation of COL1A by (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

[0078] FIG. 49D depicts modulation of aSMA by (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

[0079] FIG. 49E depicts modulation of CCMP by (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

[0080] FIG. 49F depicts modulation of TGFB1 by (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

[0081] FIG. 50 depicts modulation of COL1, aSMA and FN by (S)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

[0082] FIG. 51 depicts modulation of MMP1 and PAI by (S)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

[0083] FIG. 52 depicts modulation of Dnmt1 by (S)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

[0084] FIG. 53 depicts the mRNA expression level of cereblon in normal and SSc fibroblasts.

[0085] FIG. 54 depicts the mRNA expression level of cereblon in normal and SSc skin tissues.

7. DETAILED DESCRIPTION

[0086] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as is commonly understood by one of ordinary skill in the art. All patents, applications, published applications and other publications are incorporated by reference in their entirety. In the event that there is a plurality of definitions for a term herein, those in this section prevail unless stated otherwise.

[0087] As used herein, and unless otherwise indicated, the terms "treat," "treating" and "treatment" refer to alleviating or reducing the severity of a disease or a symptom associated with the disease or condition being treated.

[0088] As used herein, "prevent", "prevention" and other forms of the word include the inhibition of onset or progression of a disease or disorder or a symptom of the particular disease or disorder. In some embodiments, subjects with familial history of cancer are candidates for preventive regimens. Generally, in the context of cancer, the term "preventing" refers to administration of the drug prior to the onset of signs or symptoms of a cancer, particularly in subjects at risk of cancer.

[0089] As used herein, and unless otherwise indicated, the term "managing" encompasses preventing the recurrence of the particular disease or disorder in a subject who had suffered from it, lengthening the time a subject who had suffered from the disease or disorder remains in remission, reducing mortality rates of the subjects, and/or maintaining a reduction in severity or avoidance of a symptom associated with the disease or condition being managed.

[0090] As used herein, "subject" means an animal, typically a mammal, including a human being. As used herein, "patient" means a human subject.

[0091] As used herein, and unless otherwise specified, the terms "therapeutically effective amount" and "effective amount" of a compound refer to an amount sufficient to provide a therapeutic benefit in the treatment, prevention and/or management of a disease, to delay or minimize one or more symptoms associated with the disease or disorder to be treated. The terms "therapeutically effective amount" and "effective amount" can encompass an amount that improves overall therapy, reduces or avoids symptoms or causes of disease or disorder or enhances the therapeutic efficacy of another therapeutic agent.

[0092] As used herein, and unless otherwise specified, the term "prophylactically effective amount" of a compound is an amount sufficient to prevent a disease or condition, or one or more symptoms associated with the disease or condition, or prevent its recurrence. A prophylactically effective amount of a compound means an amount of therapeutic agent, alone or in combination with other agents, which provides a prophylactic benefit in the prevention of the disease. The term "prophylactically effective amount" can encompass an amount that improves overall prophylaxis or enhances the prophylactic efficacy of another prophylactic agent.

[0093] As used herein and unless otherwise indicated, the term "pharmaceutically acceptable salt" includes, but is not limited to, a salt of an acidic group that can be present in the compounds provided herein. Under certain acidic conditions, the compound can form a wide variety of salts with various inorganic and organic acids. The acids that can be used to prepare pharmaceutically acceptable salts of such basic compounds are those that form salts comprising pharmacologically acceptable anions including, but not limited to, acetate, benzenesulfonate, benzoate, bicarbonate, bitartrate, bromide, calcium edetate, camsylate, carbonate, chloride, bromide, iodide, citrate, dihydrochloride, edetate, edisylate, estolate, esylate, fumarate, gluceptate, gluconate, glutamate, glycollylarsanilate, hexylresorcinate, hydrabamine, hydroxynaphthoate, isethionate, lactate, lactobionate, malate, maleate, mandelate, methanesulfonate (mesylate), methylsulfate, muscate, napsylate, nitrate, pantothenate, phosphate/diphosphate, polygalacturonate, salicylate, stearate, succinate, sulfate, tannate, tartrate, teoclate, triethiodide, and pamoate.

[0094] As used herein and unless otherwise indicated, the term "hydrate" means a compound provided herein or a salt thereof, further including a stoichiometric or non-stoichiometric amount of water bound by non-covalent intermolecular forces. The hydrates can be crystalline or non-crystalline.

[0095] As used herein and unless otherwise indicated, the term "solvate" means a solvate formed from the association of one or more solvent molecules to compound provided herein. The term "solvate" includes hydrates (*e.g.*, monohydrate, dihydrate, trihydrate, tetrahydrate, and the like). The solvates can be crystalline or non-crystalline.

[0096] As used herein, and unless otherwise specified, the term "stereoisomer" encompasses all enantiomerically/stereomerically pure and enantiomerically/stereomerically enriched compounds provided herein.

[0097] As used herein, and unless otherwise indicated, the term "stereomerically pure" or "enantiomerically pure" means that a compound comprises one stereoisomer and is substantially free of its counter stereoisomer or enantiomer. For example, a compound is stereomerically or enantiomerically pure when the compound contains

80%, 90%, or 95% or more of one stereoisomer and 20%, 10%, or 5% or less of the counter stereoisomer. In certain cases, a compound provided herein is considered optically active or stereomerically/enantiomerically pure (*i.e.*, substantially the *R*-form or substantially the *S*-form) with respect to a chiral center when the compound is about 80% ee (enantiomeric excess) or greater, preferably, equal to or greater than 90% ee with respect to a particular chiral center, and more preferably 95% ee with respect to a particular chiral center.

[0098] As used herein, and unless otherwise indicated, the term "stereomerically enriched" or "enantiomerically enriched" encompasses racemic mixtures as well as other mixtures of stereoisomers of compounds provided herein (*e.g.*, R/S = 30/70, 35/65, 40/60, 45/55, 55/45, 60/40, 65/35 and 70/30).

[0099] The terms "co-administration" and "in combination with" include the administration of two or more therapeutic agents (for example, Compound I or a composition provided herein and another modulator of leukocytic activity, including activity of B cells and/or T cells, monocytes, macrophages, and other lymphoid or myeloid-derived cell types or other active agent) either simultaneously, concurrently or sequentially with no specific time limits. In one embodiment, Compound I and at least one other agent are present in the cell or in the subject's body at the same time or exert their biological or therapeutic effect at the same time. In one embodiment, the therapeutic agent(s) are in the same composition or unit dosage form. In another embodiment, the therapeutic agent(s) are in separate compositions or unit dosage forms.

[00100] A "B cell" is a lymphocyte that matures within the bone marrow, and includes a naive B cell, memory B cell, or effector B cell (plasma cells). The B cell herein may be a normal or non-malignant B cell.

[00101] A "T cell" is a lymphocyte that matures in thymus, and includes a helper T cell, a memory T cell, and a cytotoxic T cell.

[00102] As used herein "overall survival" refers to the time from randomization until death from any cause, and is measured in the intent-to-treat population. Overall survival can be evaluated in randomized controlled studies.

[00103] As used herein "objective response rate" refers to the proportion of patients with reduced predefined scleroderma symptoms at the end of a predefined period of time. Response duration is usually measured from the time of initial response until documented scleroderma progression.

[00104] As used herein "time to progression" means the time from randomization until objective scleroderma progression. In certain embodiments, time to progression does not include deaths.

[00105] As used herein "progression-free survival" means the time from randomization until objective scleroderma progression or death.

[00106] As used herein "time-to-treatment failure" means any endpoint(s) measuring time from randomization to discontinuation of treatment for any reason, including disease progression, treatment toxicity, and death.

[00107] As used herein "mortality" means a measure of the number of deaths in a given population.

[00108] As used herein "respiratory mortality" means patients who die from acute hypoxemia or other specific respiratory deterioration resulting in death such as need for mechanical ventilation leading to death, respiratory arrest, or any other event in a subject deemed to be respiratory in nature.

[00109] As used herein "respiratory hospitalization" means those hospitalized for deterioration in pulmonary status as documented by patient hospital admission notes or other medical opinion.

[00110] As used herein "modified Rodnan skin score" means a validated numerical scoring system to assess dermal skin thickness.

[00111] As used herein "skin thickness" means hard or indurated skin that can be evaluated using a variety of techniques including durometer and mRSS

[00112] As used herein "skin induration" means skin that is hardened, red, inflamed, thickened or tender.

[00113] As used herein "dermatology quality of life index" means an evaluation of quality or life related to the skin symptoms for a patient having scleroderma.

[00114] As used herein "pulmonary function" means any measurement of forced expiratory flow, forced vital capacity, FEV 25-75%, lung volumes or vital capacity.

[00115] As used herein "carbon monoxide diffusing capacity" means an assessment of the uptake of carbon monoxide across the alveolar-capillary membrane. It can be a proxy for the measurement of the lungs ability to transfer oxygen from the lungs to the blood stream.

[00116] As used herein "Mahler Dyspnea index" means an instrument that provides clinical measurement of shortness of breath.

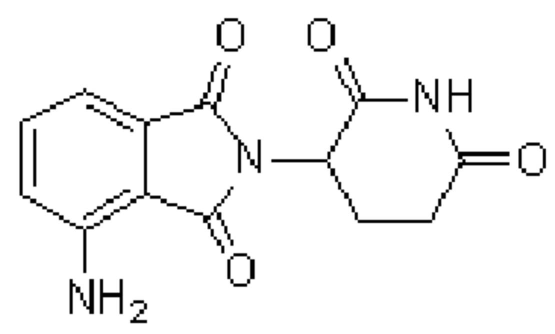
[00117] As used herein "Saint George's Respiratory Questionnaire score" means an instrument that measures quality of life in patients with pulmonary disease.

[00118] As used herein "UCLA scleroderma clinical trial consortium gastrointestinal tract score" means a questionnaire administered to patients having scleroderma to evaluate gastrointestinal symptoms associated with scleroderma (systemic sclerosis).

[00119] As used herein "flow-mediated dilatation" means any measurement of vascular endothelial function in a patient having scleroderma.

[00120] As used herein "six minute walk distance" means any evaluation of the distance a patient having scleroderma can walk within 6 minutes or any standardized procedure to evaluate ability to walk for a fixed period of time or distance.

[00121] As used herein, pomalidomide refers to the following compound:



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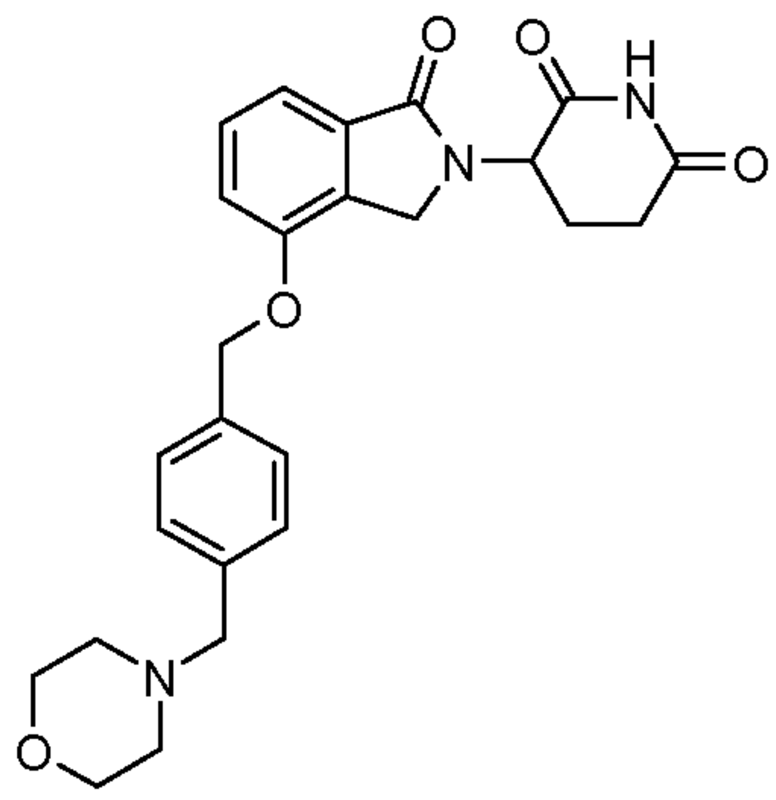
7.1 COMPOUND I

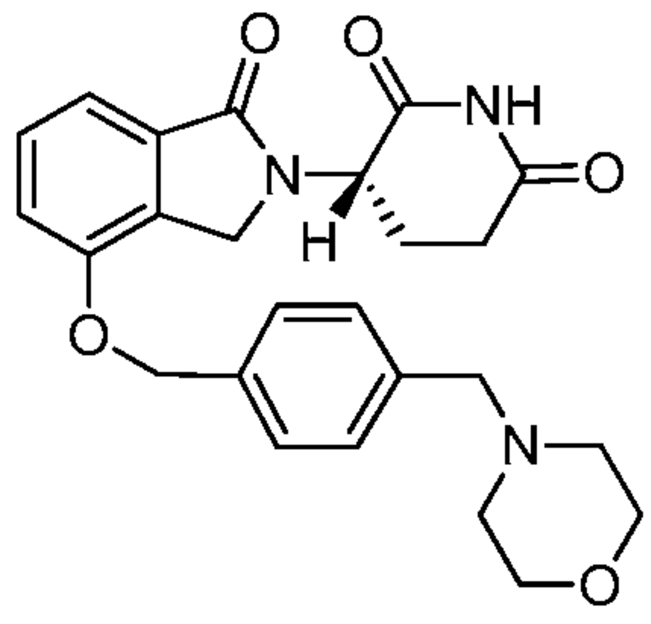
[00122] In certain embodiments, Compound I for use in the methods provided herein, including the combination therapy, and in compositions provided herein is a compound of formula:



Compound I,

or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof.

[00123] In one embodiment, the compound is (*S*)-3-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-piperidine-2,6-dione, having the following structure:

 Compound IA,

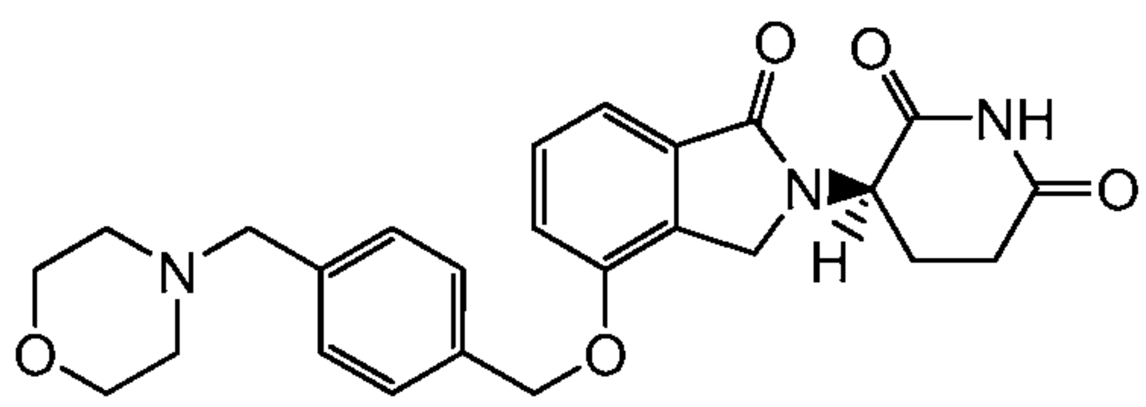
or a pharmaceutically acceptable salt, solvate, hydrate, or tautomer thereof.

[00124] In one embodiment, the compound is (*S*)-3-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-piperidine-2,6-dione.

[00125] In one embodiment, the compound is a pharmaceutically acceptable salt of (*S*)-3-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-piperidine-2,6-dione.

[00126] In one embodiment, the compound is (*S*)-3-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-piperidine-2,6-dione hydrochloride.

[00127] In one embodiment, the compound is (*R*)-3-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-piperidine-2,6-dione, having the following structure:

 Compound IB,

or a pharmaceutically acceptable salt, solvate, hydrate, or tautomer thereof.

[00128] In one embodiment, the compound is (*R*)-3-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-piperidine-2,6-dione.

[00129] In one embodiment, the compound is a pharmaceutically acceptable salt of (*R*)-3-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-piperidine-2,6-dione.

[00130] In one embodiment, the compound is selected from 3-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-piperidine-2,6-dione, 3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione hydrochloride, (*R*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione, (*R*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione hydrochloride, (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione and (*S*)-3-[4-

(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione hydrochloride.

[00131] Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof can be prepared by methods known to one of skill in the art, for example, according to the procedure described in US Publication No. 2011/0196150, the entirety of which is incorporated herein by reference.

[00132] An exemplary method for preparation is described in Example 1.

7.2 METHODS OF TREATMENT

[00133] Provided herein are methods of treating, preventing, and/or managing diseases, disorders and/or conditions associated with immune-related and inflammatory diseases comprising administering a therapeutically effective amount of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof to a patient in need thereof. In certain embodiments, the disease is selected from lupus, scleroderma, Sjögren syndrome, ANCA-induced vasculitis, anti-phospholipid syndrome and myasthenia gravis. In certain embodiments, the disease is lupus or scleroderma.

[00134] The sensitivity of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof can be studied in various *in vivo* and *in vitro* assays, including animal models known to one of skill in the art for immune-related and inflammatory diseases, including, but not limited to MRL/MpJ-Faslpr/J mouse model of systemic lupus erythematosus, NZBWF1/J mouse model of systemic lupus erythematosus, bleomycin-induced skin fibrosis model, and murine tight skin-1 (Tsk-1) mouse model.

7.2.1 Treatment of Scleroderma

[00135] In certain embodiments, provided herein are methods of treating, preventing, and/or managing scleroderma or a symptom thereof, comprising administering a therapeutically effective amount of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof to a patient having scleroderma. In one embodiment, provided herein are methods of treating, preventing, and/or managing scleroderma or a symptom thereof, comprising administering an effective amount of (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione or a pharmaceutically acceptable salt thereof.

[00136] In certain embodiments, provided herein are methods of preventing scleroderma or a symptom thereof, comprising administering an effective amount of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof to a patient at risk of having scleroderma. In one embodiment, provided herein are methods of preventing scleroderma or a symptom thereof, comprising administering an effective amount of (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione or a pharmaceutically acceptable salt thereof.

[00137] In certain embodiments, the scleroderma is localized, systemic, limited or diffuse scleroderma.

[00138] In certain embodiments, the systemic scleroderma comprises CREST syndrome (Calcinosis, Raynaud's syndrome, esophagaeal dysfunction or dysmotility, sclerodactyly, telangiectasia). Scleroderma is also known as systemic sclerosis or progressive systemic sclerosis. In certain embodiments, provided herein are methods of treating or preventing Raynaud's disease or syndrome. In certain embodiments, systemic sclerosis comprises scleroderma lung disease, scleroderma renal crisis, cardiac manifestations, muscular weakness (including fatigue or limited CREST), gastrointestinal dysmotility and spasm, and abnormalities in the central, peripheral and autonomic nervous system (including carpal tunnel syndrome followed by trigeminal neuralgia). It also includes general disability, including depression, and impact on quality of life.

[00139] In certain embodiments, limited scleroderma is limited to the hands, the face, neck, or combinations thereof.

[00140] In certain embodiments, diffuse scleroderma comprises skin tightening and also occurs above the wrists (or elbows). In certain embodiments, the diffuse systemic sclerosis is sine scleroderma, comprising internal organ fibrosis, but no skin tightening; or familial progressive systemic sclerosis.

[00141] In one embodiment, scleroderma is not associated with wasting, such as disease-related wasting.

[00142] In one embodiment, provided herein are methods for the reduction, inhibition, or prevention of one or more of the following symptoms of scleroderma: (i) gradual hardening, thickening, and tightening of the skin (e.g., in extremities, such as hands, face, and feet); (ii) skin discoloration; (iii) numbness of extremities; (iv) shiny skin; (v) small white lumps under the surface of the skin that erupt into a chalky white fluid; (vi) Raynaud's esophagaeal dysfunction (pain, numbness, and/or color changes in the hands caused by spasm of the blood vessels upon exposure to cold or emotional stress); (vii) telangiectasia (red spots on, e.g., the hands, palms, forearms, face, and lips); (viii) pain and/or stiffness of the joints; (ix) swelling of the hands and feet; (x) itching of the skin; (xi) stiffening and curling of the fingers; (xii) ulcers (sores) on the outside of certain joints, such as knuckles and elbows; (xiii) digestive problems, such as heartburn, difficulty in swallowing, diarrhea, irritable bowel, and constipation; (xiv) fatigue and weakness; (xv) shortness of breath; (xvi) arthritis; (xvii) hair loss; (xviii) internal organ problems; (xix) digital ulcers; or (xx) digital auto-amputation, comprising administering an effective amount of Compound I to a patient in need thereof.

[00143] Without being bound to any particular theory, it is believed that Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof enhances Th1 immune response, and suppresses Th2 immune response, which may result in anti-fibrotic effects in the skin.

[00144] Further provided herein are methods for improving or reducing the skin thickness of a patient having scleroderma comprising administering an effective amount of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof to the patient. In one embodiment, the skin thickness is reduced by about 20%, about 25%, about 30%, about 40%, about 50%, about 60%, about 70% about 80%, about 90% or more.

[00145] Further provided herein are methods for achieving one or more clinical endpoints associated with scleroderma comprising administering an effective amount of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof to a patient in need thereof.

[00146] Further provided herein are methods for increasing the overall survival, objective response rate, time to progression, progression-free survival and/or time-to-treatment failure of a patient having scleroderma comprising administering an effective amount of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof to the patient.

[00147] Further provided herein are methods for decreasing mortality, respiratory mortality and/or respiratory hospitalization of a patient having scleroderma comprising administering an effective amount of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof to the patient.

[00148] Further provided herein are methods for improving the modified Rodnan skin score of a patient having scleroderma comprising administering an effective amount of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof to the patient. In one embodiment, the improvement in modified Rodnan skin score is 5, 10, 15 or 20 points or more.

[00149] Further provided herein are methods for improving or reducing the skin thickness of a patient having scleroderma comprising administering an effective amount of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof to the patient. In one embodiment, the skin thickness is reduced by about 20%, about 25%, about 30%, about 40%, about 50%, about 60%, about 70% about 80%, about 90% or more.

[00150] Further provided herein are methods for improving or reducing skin induration of a patient having scleroderma comprising administering an effective amount of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof to the patient.

[00151] Further provided herein are methods for improving the dermatology quality of life index of a patient having scleroderma comprising administering an effective amount of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof to the patient.

[00152] Further provided herein are methods for improving the pulmonary function of a patient having scleroderma comprising administering an effective amount of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof to the patient.

[00153] Further provided herein are methods for improving the carbon monoxide diffusing capacity of a patient having scleroderma comprising administering an effective amount of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof to the patient. In one embodiment, the carbon monoxide diffusing capacity of a patient is improved by an improvement in the diffusing capacity of the lung for carbon monoxide (D_Lco) of about 10%, about 20%, about 25%, about 30%, about 40%, about 50%, about 60%, about 70% about 80%, about 90% or more.

[00154] Further provided herein are methods for improving the Mahler Dyspnea index of a patient having scleroderma comprising administering an effective amount of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof to the patient. In one embodiment, the improvement in Mahler Dyspnea index is 4, 5, 6, 7, 8, 9 or 10 points or more.

[00155] Further provided herein are methods for improving the Saint George's Respiratory Questionnaire score of a patient having scleroderma comprising administering an effective amount of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof to the patient. .In one embodiment, the improvement in Saint George’s Respiratory Questionnaire score is 4, 8, 12, 16, 20, 24, 28, 32, 36, 40, 44, 48, 52 points or more.

[00156] Further provided herein are methods for improving the UCLA scleroderma clinical trial consortium gastrointestinal tract score of a patient having scleroderma comprising administering an effective amount of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof to the patient.

[00157] Further provided herein are methods for treating or preventing digital ulcer of a patient or patient population having scleroderma comprising administering an effective amount of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof to the patient.

[00158] Further provided herein are methods improving flow-mediated dilatation of a patient having scleroderma comprising administering an effective amount of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof to the patient.

[00159] Further provided herein are methods improving or increasing the six minute walk distance of a patient having scleroderma comprising administering an effective amount of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof to the patient. In one embodiment, the improvement in the six minute walk distance is about 200 meters, about 250 meters, about 300 meters, about 350 meters, about 400 meters or more.

7.2.2 Treatment of Lupus Erythematosus

[00160] In certain embodiments, provided herein are methods of treating, preventing, and/or managing lupus erythematosus or a symptom thereof, comprising administering a therapeutically effective amount of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof to a patient having lupus erythematosus. In one embodiment, provided herein are methods of treating, preventing, and/or managing lupus erythematosus or a symptom thereof, comprising administering a therapeutically effective amount of (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione or a pharmaceutically acceptable salt thereof to a patient having lupus erythematosus.

[00161] In one embodiment, provided herein are methods of preventing lupus erythematosus or a symptom thereof, comprising administering an effective amount of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof to a patient at risk of having lupus erythematosus. In one embodiment, provided herein are methods of preventing lupus erythematosus or a symptom thereof, comprising administering an effective amount of (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione or a pharmaceutically acceptable salt thereof to a patient at risk of having lupus erythematosus.

[00162] In certain embodiments, provided herein are methods for treating, preventing, and/or managing systemic lupus erythematosus (SLE), cutaneous lupus erythematosus (CLE) or drug-induced lupus.

[00163] The phrase “Systemic lupus erythematosus” is interchangeably used herein with SLE and lupus and refers to all manifestations of the disease as known in the art (including remissions and flares). In SLE, abnormal hyperactivity of B lymphocytes and massive abnormal production of immunoglobulin gamma (IgG) auto-antibodies play a key role. This pathological process results in sequestration and destruction of Ig-coated cells, fixation and cleaving of complement proteins, and release of chemotaxins, vasoactive peptides and destructive enzymes into tissues (Hahn BH. Systemic Lupus Erythematosus. In: Kasper DL, Braunwald E, Fauci AS, Hauser SL, Longo DL, Jameson, JL, editors. In: *Harrison's Principles of Internal Medicine* (16th edition). New York (US): McGraw-Hill; 2005. pp.1960-1967).

[00164] Symptoms of SLE vary from person to person, and may come and go. In most patients, the symptoms include joint pain and swelling. Frequently affected joints are the fingers, hands, wrists, and knees. Some patients develop arthritis. Other common symptoms include: chest pain when taking a deep breath, fatigue, fever with no other cause, general discomfort, uneasiness, or ill feeling (malaise), hair loss, mouth sores, swollen lymph nodes, sensitivity to sunlight, skin rash -a “butterfly” rash over the cheeks and bridge of the nose affects about half of people with SLE, in some patients, the rash gets worse in sunlight, and the rash may also be widespread.

[00165] Other symptoms depend on what part of the body is affected, and may include the following:

Brain and nervous system: headaches, numbness, tingling, seizures, vision problems, personality changes,

Digestive tract: abdominal pain, nausea, and vomiting,

Heart: abnormal heart rhythms (arrhythmias),

Lung: coughing up blood and difficulty breathing, and

Skin: patchy skin color, fingers that change color when cold (Raynaud's phenomenon).

[00166] Some patients only have skin symptoms. This is called discoid lupus.

[00167] In one embodiment, provided herein are methods of treating moderate, severe, or very severe SLE. The term “severe SLE” as used herein refers to an SLE condition where the patient has one or more severe or life-threatening symptoms (such as hemolytic anemia, extensive heart or lung involvement, kidney disease, or central nervous system involvement).

[00168] Further provided herein are methods for achieving one or more clinical endpoints associated with SLE comprising administering an effective amount of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof to a patient in need thereof.

[00169] Further provided herein are methods for increasing the overall survival, objective response rate, time to progression, progression-free survival and/or time-to-treatment failure of a patient having SLE comprising administering an effective amount of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof to the patient.

[00170] In certain embodiment, Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof acts as an inhibitor of primary human memory CD19+ B-cell differentiation to the plasmablast stage. Without being bound to any particular theory, it is believed that Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof blocks cells at a premature stage thereby decreasing the numbers of plasmablasts that are capable of producing high levels of immunoglobulin. A functional consequence of this effect is reduced immunoglobulin G (IgG) and immunoglobulin M (IgM) production in these differentiation cultures.

[00171] In certain embodiments, Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof inhibits of the ability of primary human memory CD19+ B-cells to differentiate to the plasmablast stage. In certain embodiments, Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof has no significant effect on mature CD138+ plasma cells in short term cultures. In certain embodiments, Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof inhibits B cell differentiation factors including interferon regulatory factor 4 (IRF4), lymphocyte-induced maturation protein (BLIMP), X-box-protein-1 (XBP-1) and B cell lymphoma 6 (Bcl6).

7.2.3 Treatment of Other Immune-Related Diseases or Disorders

[00172] Further provided herein are methods of treating, managing, or preventing other immune-related diseases or conditions using Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof. In certain embodiments, provided herein are methods of treating, managing, or preventing other immune-related diseases or conditions using (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione or a pharmaceutically acceptable salt thereof. In certain embodiments, for example, provided herein is a method of treating an individual having a disease or disorder, wherein the disease or disorder is caused by, or is associated with, an inappropriate or undesirable immune response, *e.g.*, a disease, disorder or condition that can be treated beneficially by immunosuppression, comprising administering to the individual Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof. In certain embodiments, provided herein is a method of treating an individual having a disease or disorder, wherein the disease or disorder is caused by, or is associated with, an inappropriate or undesirable immune response, *e.g.*, a disease, disorder or condition that can be treated beneficially by immunosuppression, comprising administering to the individual (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione or a pharmaceutically acceptable salt thereof.

[00173] In various specific embodiments, said immune-related disease is one or more of selected from Sjögren syndrome, ANCA-induced vasculitis, anti-phospholipid syndrome, myasthenia gravis, Addison's disease, alopecia areata, ankylosing spondylitis, antiphospholipid antibody syndrome, antiphospholipid syndrome (primary or secondary), asthma, autoimmune gastritis, autoimmune hemolytic anemia, autoimmune hepatitis, autoimmune inner ear disease, autoimmune lymphoproliferative disease, autoimmune thrombocytopenic purpura, Balo disease, Behcet's disease, bullous pemphigoid, cardiomyopathy, celiac disease, Chagas disease, chronic inflammatory demyelinating polyneuropathy, cicatrical pemphigoid (*e.g.*, mucous membrane pemphigoid), cold agglutinin disease, degos disease, dermatitis hepatiformis, essential mixed cryoglobulinemia, Goodpasture's syndrome, Graves' disease, Guillain-Barre syndrome, Hashimoto's thyroiditis (Hashimoto's disease; autoimmune thyroditis), idiopathic pulmonary fibrosis, idiopathic thrombocytopenia purpura, IgA nephropathy, juvenile arthritis, lichen planus, Ménière disease, mixed connective tissue disease, morephea, narcolepsy, neuromyotonia, pediatric autoimmune neuropsychiatric disorders (PANDAs), pemphigus vulgaris, pernicious anemia, polyarteritis nodosa, polychondritis, polymyalgia rheumatica, primary agammaglobulinemia, primary biliary cirrhosis, Raynaud disease (Raynaud phenomenon), Reiter's syndrome, relapsing polychondritis, rheumatic fever, Sjogren's syndrome, stiff-person syndrome (Moersch-Woltmann syndrome), Takayasu's arteritis, temporal arteritis (giant cell arteritis), uveitis, vasculitis (*e.g.*, vasculitis not associated with lupus erythematosus), vitiligo, and/or Wegener's granulomatosis.

7.2.4 Treatment for Patients with Renal Impairment

[00174] In certain embodiments, provided herein are methods of treating, preventing, and/or managing a disease provided herein in patients with impaired renal function. In certain embodiments, provided herein are methods of providing appropriate dose adjustments for patients with impaired renal function due to, but not limited to, disease, aging, or other patient factors.

[00175] In certain embodiments, provided herein are methods of treating, preventing, and/or managing a disease provided herein, or a symptom thereof, in patients with impaired renal function comprising administering a therapeutically effective amount of a compound provided herein to the patient with impaired renal function. In one embodiment, provided herein are methods of treating, preventing, and/or managing relapsed disease, or a symptom thereof, in patients with impaired renal function comprising administering a therapeutically effective amount of (S)-3-(4-((4-morphlinomethyl)benzyl)oxy)-1-oxoisoindolin-2-yl)piperidine-2,6-dione or a pharmaceutically acceptable salt thereof to a patient having relapsed disease with impaired renal function.

[00176] In one embodiment, provided herein are methods of preventing a relapse in patients with impaired renal function, comprising administering an effective amount of a compound provided herein to a patient with impaired renal function at risk of having a relapse. In one embodiment, provided herein are methods of preventing a relapse in patients with impaired renal function, comprising administering an effective amount of (S)-3-(4-((4-morphlinomethyl)benzyl)oxy)-1-oxoisoindolin-2-yl)piperidine-2,6-dione or a pharmaceutically acceptable salt thereof, to a patient with impaired renal function at risk of having a relapse.

[00177] In all of the embodiments provided herein, when a renally impaired patient is treated, there is a need for administering to the renally impaired patient a dose of the compound lower than the dose administered to a normal patient (*e.g.*, a patient without renal impairment) because of the decreased ability of the renally impaired patient in eliminating pomalidomide or its metabolites. Thus, in one embodiment, provided herein is a method for treating a renally impaired patient with a dose of a compound provided herein lower than the dose administered to a normal patient.

[00178] In certain embodiments, a therapeutically or prophylactically effective amount of the compound is from about 0.005 to about 1,000 mg per day, from about 0.01 to about 500 mg per day, from about 0.01 to about 250 mg per day, from about 0.01 to about 100 mg per day, from about 0.1 to about 100 mg per day, from about 0.5 to about 100 mg per day, from about 1 to about 100 mg per day, from about 0.01 to about 50 mg per day, from about 0.1 to about 50 mg per day, from about 0.5 to about 50 mg per day, from about 1 to about 50 mg per day, from about 0.02 to about 25 mg per day, or from about 0.05 to about 10 mg per day.

7.3 <u>DOSAGES AND DOSING AMOUNTS</u>

[00179] The dose of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof to be administered to a patient is rather widely variable and can be subject to the judgment of a health-care practitioner. Doses of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof vary depending on factors such as: specific indication to be treated, prevented, or managed; age and condition of a patient; and amount of second active agent used, if any. In general, Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof can be administered one to four or more times a day in a dose of about 0.005 mg/kg of a patient's body weight to about 10 mg/kg of a patient's body weight in a patient, but the above dosage may be properly varied depending on the age, body weight and medical condition of the patient and the type of administration. In one embodiment, the dose is about 0.01 mg/kg of a patient's body weight to about 5 mg/kg of a patient's body weight, about 0.05 mg/kg of a patient's body weight to about 1 mg/kg of a patient's body weight, about 0.1 mg/kg of a patient's body weight to about 0.75 mg/kg of a patient's body weight or about 0.25 mg/kg of a patient's body weight to about 0.5 mg/kg of a patient's body weight.

[00180] In one embodiment, one dose is given per day. In any given case, the amount of Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof administered will depend on such factors as the solubility of the active component, the formulation used and the route of administration. In one embodiment, application of a topical concentration provides intracellular exposures or concentrations of about 0.01 – 10 μM.

[00181] In certain embodiments, Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof is used in an amount of from about 0.1 mg to about 1000 mg per day, and can be adjusted in a conventional fashion (*e.g.*, the same amount administered each day of the treatment, prevention or management period), in cycles (*e.g.*, one week on, one week off), or in an amount that increases or decreases over the course of treatment, prevention, or management. In other embodiments, the dose can be from about 1 mg to about 300 mg, from about 0.1 mg to about 150 mg, from about 1 mg to about 200 mg, from about 10 mg to about 100 mg, from about 0.1 mg to about 50 mg, from about 1 mg to about 50 mg, from about 10 mg to about 50 mg, from about 20 mg to about 30 mg, or from about 1 mg to about 20 mg. In other embodiments, the dose can be from about 0.1 mg to about 100 mg, from about 0.1 mg to about 50 mg, from about 0.1 mg to about 25 mg, from about 0.1 mg to about 20 mg, from about 0.1 mg to about 15 mg, from about 0.1 mg to about 10 mg, from about 0.1 mg to about 7.5 mg, from about 0.1 mg to about 5 mg, from about 0.1 mg to about 4 mg, from about 0.1 mg to about 3 mg, from about 0.1 mg to about 2 mg, or from about 1 mg to about 1 mg.

7.4 COMBINATION THERAPY

[00182] Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof can be combined with other pharmacologically active compounds ("second active agents") in methods and compositions provided herein. Certain combinations may work synergistically in the treatment of particular types diseases or disorders, and conditions and symptoms associated with such diseases or disorders. Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof can also work to alleviate adverse effects associated with certain second active agents, and vice versa.

[00183] One or more second active ingredients or agents can be used in the methods and compositions provided herein. Second active agents can be large molecules (e.g., proteins) or small molecules (e.g., synthetic inorganic, organometallic, or organic molecules).

[00184] In another embodiment, the method of treatment provided herein comprises the administration of a second therapeutic agent, wherein the second therapeutic agent is an anti-inflammatory drug, *e.g.*, a steroidal anti-inflammatory drug, or a non-steroidal anti-inflammatory drug (NSAID), acetaminophen, naproxen, ibuprofen, acetylsalicylic acid, and the like. In a more specific embodiment in which an NSAID is administered, a proton pump inhibitor (PPI), *e.g.*, omeprazole may also administered. In one embodiment, the antiinflammatory agent is a corticosteroid. In another embodiment, the antiinflammatory agent is colchicine.

[00185] In another embodiment, the second therapeutic agent is an immunomodulatory compound or an immunosuppressant compound such as azathioprine (Imuran™, Azasan™), methotrexate (Rheumatrex™, Trexall™), penicillamine (Depen™, Cuprimine™), cyclophosphamide (Cytoxan™), mycophenalate (CellCept™, Myfortic™), bosentan (Tracleer®), prednisone (Deltasone™, Liquid Pred™), and a PDE5 inhibitor. In another embodiment, where the affected individual has digital ulcerations and pulmonary hypertension, a vasodilator such as prostacyclin (iloprost) may be administered.

[00186] In another embodiment, the second therapeutic agent is an HDAC inhibitor, such as romidepsin, vorinostat, panobinostat, valproic acid, or belinostat; or a biological agent, such as an interleukin, an immunomodulatory monoclonal antibody, or bacillus Calmette-Guérin (BCG).

[00187] In another embodiment, the second therapeutic agent is an inhibitor of ActRII receptors or an activin-ActRII inhibitor. Inhibitors of ActRII receptors include ActRIIA inhibitors and ActRIIB inhibitors. Inhibitors of ActRII receptors can be polypeptides comprising activin-binding domains of ActRII. In certain embodiments, the activin-binding domain comprising polypeptides are linked to an Fc portion of an antibody (*i.e.*, a conjugate comprising an activin-binding domain comprising polypeptide of an ActRII receptor and an Fc portion of an antibody is generated). In certain embodiments, the activin-binding domain is linked to an Fc portion of an antibody via a linker, *e.g.,* a peptide linker.

[00188] An exemplary activin-binding ActRIIA polypeptide fused to a human Fc domain is provided in SEQ ID NO: 1.

SEQ ID NO:1

ILGRSETQECLFFNANWEKDRTNQTGVEPCYGDKDKRRHCFATWKNISGS
IEIVKQGCWLDDINCYDRTDCVEKKDSPEVYFCCCEGNMCNEKFSYFPEM
EVTQPTSNPVTPKPPTGGGTHTCPPCPAPELLGGPSVFLFPPKPKDTLMI
SRTPEVTCVVVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVV
SVLTVLHQDWLNGKEYKCKVSNKALPVPIEKTISKAKGQPREPQVYTLPP
SREEMTKNQVSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGS
FFLYSKLTVDKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK

[00189] An exemplary fusion protein comprising a soluble extracellular domain of ActRIIB fused to an Fc domain is provided in SEQ ID NO: 2.

SEQ ID NO:2

ETRECIYYNANWELERTNQSGLERCEGEQDKRLHCYASWRNSSGTIELVK
KGCWDDDFNCYDRQECVATEENPQVYFCCCEGNFCNERFTHLPEAGGPEV
TYEPPPTGGGTHTCPPCPAPELLGGPSVFLFPPKPKDTLMISRTPEVTCV
VVDVSHEDPEVKFNWYVDGVEVHNAKTKPREEQYNSTYRVVSVLTVLHQD
WLNGKEYKCKVSNKALPAPIEKTISKAKGQPREPQVYTLPPSREEMTKNQ
VSLTCLVKGFYPSDIAVEWESNGQPENNYKTTPPVLDSDGSFFLYSKLTV
DKSRWQQGNVFSCSVMHEALHNHYTQKSLSLSPGK

[00190] Further examples of non-antibody proteins selected for activin or ActRIIA binding and methods for design and selection of the same are found in WO/2002/088171, WO/2006/055689, WO/2002/032925, WO/2005/037989, US 2003/0133939, and US 2005/0238646, each of which is incorporated herein by reference in its entirety.

[00191] In one embodiment, the inhibitor of ActRII receptors is ACE-11. In another embodiment, the inhibitor of ActRII receptors is ACE-536.

[00192] Any combination of the above therapeutic agents, suitable for treatment of the diseases or symptoms thereof, can be administered. Such therapeutic agents can be administered in any combination with Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof, at the same time or as a separate course of treatment.

7.5 CYCLING THERAPY

[00193] In certain embodiments, Compound I or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof provided herein is cyclically administered to a patient. Cycling therapy involves the administration of an active agent for a period of time, followed by a rest (*i.e.*, discontinuation of the administration) for a period of time, and repeating this sequential administration. Cycling therapy can reduce the development of resistance to one or more of the therapies, avoid or reduce the side effects of one of the therapies, and/or improve the efficacy of the treatment.

[00194] Consequently, in one embodiment, a compound provided herein is administered daily in a single or divided doses in a four to six week cycle with a rest period of about a week or two weeks. Cycling therapy further allows the frequency, number, and length of dosing cycles to be increased. Thus, another embodiment encompasses the administration of a compound provided herein for more cycles than are typical when it is administered alone. In yet another embodiment, a compound provided herein is administered for a greater number of cycles than would typically cause dose-limiting toxicity in a patient to whom a second active ingredient is not also being administered.

[00195] In one embodiment, a compound provided herein is administered daily and continuously for three or four weeks at a dose of from about 0.03 mg to about 10 mg per day, followed by a rest of one or two weeks. In other embodiments, the dose can be from about 0.1 mg to about 8 mg, from about 0.3 mg to about 6 mg, from about 1 mg to about 4 mg, or about 2 mg, followed by a rest.

[00196] In one embodiment, a compound provided herein and a second active ingredient are administered orally, with administration of the compound provided herein occurring 30 to 60 minutes prior to the second active ingredient, during a cycle of four to six weeks. In another embodiment, the combination of a compound provided herein and a second active ingredient is administered by intravenous infusion over about 90 minutes every cycle.

[00197] Typically, the number of cycles during which the combination treatment is administered to a patient will be from about one to about 24 cycles, from about two to about 16 cycles, or from about four to about three cycles.

7.6 BIOMARKERS

[00198] In certain embodiments, provided herein are biomarkers for the treatment of various disease or disorders provided herein. In one embodiment, the biomarker is cluster of differentiation-44 ("CD44"), a molecule found on the surface of B cells. In another embodiment, the biomarker is cluster of differentiation-83 ("CD83"), a molecule found on the surface of B cells. In other embodiments, the biomarker is a combination of CD44 and CD83.

[00199] The levels of the protein biomarkers provided herein can be detected or quantitated by any methods known in the art. In certain embodiments, antibody-based methods are used. In certain embodiments, the detecting or quantitating method is immunoblotting (western blot), an enzyme-linked immunosorbent assay (ELISA), immunohistochemistry, flow cytometry, a cytometric bead array, or mass spectroscopy.

[00200] In certain embodiments, the detecting or quantitating method is immunoblotting (western blot). In certain embodiments, the detecting or quantitating method is an enzyme-linked immunosorbent assay (ELISA). In certain embodiments, the detecting or quantitating method is a direct ELISA. In certain embodiments, the detecting or quantitating method is an indirect ELISA. In certain embodiments, the detecting or quantitating method is an sandwich ELISA. In certain embodiments, the detecting or quantitating method is immunohistochemistry. In certain embodiments, the detecting or quantitating method is flow cytometry. In certain embodiments, the detecting or quantitating method is a cytometric bead array. In certain embodiments, the detecting or quantitating method is mass spectroscopy.

[00201] Certain embodiments include methods of identifying a subject who is likely to be responsive to a treatment of a disease, disorder, or condition with a treatment compound. In certain embodiments the method involves determining the level of a biomarker in a biological sample from the subject. In certain embodiments the biomarker is CD44. In certain embodiments the biomarker is CD83.

[00202] In certain embodiments methods of identifying a subject who is likely to be responsive to a treatment of a disease, disorder, or condition with a treatment compound, comprise: a) determining the level of a biomarker in a biological sample from the subject, wherein the biomarker is CD44, CD83 or combination thereof; and b) comparing the level of the biomarker in the biological sample from the subject to a reference level of the biomarker; wherein the subject is likely to be responsive to the treatment if the level of the biomarker in the biological sample from the subject is altered as compared to the reference level of the biomarker.

[00203] In certain embodiments methods of identifying a subject who is likely to be responsive to a treatment of a disease, disorder, or condition with a treatment compound, comprise: a) determining the level of a biomarker in a biological sample from the subject, wherein the biomarker is CD44, CD83 or combination thereof; b) determining the level of the biomarker in a control sample; and c) comparing the level of the biomarker in the biological sample from the subject to the level of the biomarker in the control sample; wherein the subject is likely to be responsive to the treatment if the level of the biomarker in the biological sample from the subject is altered as compared to the level of the biomarker in the control sample.

[00204] In certain embodiments methods of identifying a subject who is likely to be responsive to a treatment of a disease, disorder, or condition with a treatment compound, comprise: a) determining the level of a biomarker in a biological sample from the subject, wherein the biomarker is CD83; and b) comparing the level of the biomarker in the biological sample from the subject to a reference level of the biomarker; wherein the subject is likely to be responsive to the treatment if the level of the biomarker in the biological sample from the subject is higher than the reference level of the biomarker.

[00205] In certain embodiments methods of identifying a subject who is likely to be responsive to a treatment of a disease, disorder, or condition with a treatment compound, comprise: a) determining the level of a biomarker in a biological sample from the subject, wherein the biomarker is CD83; b)determining the level of the biomarker in a control sample; and c) comparing the level of the biomarker in the biological sample from the subject to the level of the biomarker in the control sample; wherein the subject is likely to be responsive to the treatment if the level of the biomarker in the biological sample from the subject is higher than the level of the biomarker in the control sample.

[00206] In certain embodiments methods of identifying a subject who is likely to be responsive to a treatment of a disease, disorder, or condition with a treatment compound, comprise: a) determining the level of a biomarker in a biological sample from the subject, wherein the biomarker is CD44; and b) comparing the level of the biomarker in the biological sample from the subject to a reference level of the biomarker; wherein the subject is likely to be responsive to the treatment if the level of the biomarker in the biological sample from the subject is lower than the reference level of the biomarker.

[00207] In certain embodiments methods of identifying a subject who is likely to be responsive to a treatment of a disease, disorder, or condition with a treatment compound, comprise: a) determining the level of a biomarker in a biological sample from the subject, wherein the biomarker is CD44; b) determining the level of the biomarker in a control sample; and c) comparing the level of the biomarker in the biological sample from the subject to the level of the biomarker in the control sample; wherein the subject is likely to be responsive to the treatment if the level of the biomarker in the biological sample from the subject is lower than the level of the biomarker in the control sample.

[00208] In certain embodiments methods of predicting the responsiveness of a subject to a treatment of a disease, disorder, or condition with a treatment compound, comprise: a) determining the level of a biomarker in a biological sample from the subject, wherein the biomarker is CD44, CD83 or combination thereof; and b) comparing the level of the biomarker in the biological sample to a reference level of the biomarker; wherein the difference between the level of the biomarker in the biological sample from the subject and the reference level of the biomarker correlates with the responsiveness of the subject to the treatment.

[00209] In certain embodiments methods of predicting the responsiveness of a subject to a treatment of a disease, disorder, or condition with a treatment compound, comprise: a) determining the level of a biomarker in a biological sample from the subject, wherein the biomarker is CD44, CD83 or combination thereof; b) determining the level of the biomarker in a control sample; and c) comparing the level of the biomarker in the biological sample from the subject to the level of the biomarker in the control sample; wherein the difference between the level of the biomarker in the biological sample from the subject and the level of the biomarker in the control sample correlates with the responsiveness of the subject to the treatment.

[00210] In certain embodiments methods of predicting the responsiveness of a subject to a treatment of a disease, disorder, or condition with a treatment compound, comprise: a) determining the level of a biomarker in a biological sample from the subject, wherein the biomarker is CD83; and b) comparing the level of the biomarker in the biological sample to a reference level of the biomarker, wherein an increased level of the biomarker in the biological sample from the subject in comparison with the reference level of the biomarker correlates with an increased responsiveness of the subject to the treatment.

[00211] In certain embodiments methods of predicting the responsiveness of a subject to a treatment of a disease, disorder, or condition with a treatment compound, comprise: a) determining the level of a biomarker in a biological sample from the subject, wherein the biomarker is CD83; b) determining the level of the biomarker in a control sample; and c) comparing the level of the biomarker in the biological sample from the subject to the level of the biomarker in the control sample; wherein an increased level of the biomarker in the biological sample from the subject in comparison with the level of the biomarker in the control sample correlates with an increased responsiveness of the subject to the treatment.

[00212] In certain embodiments methods of predicting the responsiveness of a subject to a treatment of a disease, disorder, or condition with a treatment compound, comprise: a) determining the level of a biomarker in a biological sample from the subject, wherein the biomarker is CD44; and b) comparing the level of the biomarker in the biological sample to a reference level of the biomarker, wherein a decreased level of the biomarker in the biological sample from the subject in comparison with the reference level of the biomarker correlates with an increased responsiveness of the subject to the treatment.

[00213] In certain embodiments methods of predicting the responsiveness of a subject to a treatment of a disease, disorder, or condition with a treatment compound, comprise: a) determining the level of a biomarker in a biological sample from the subject, wherein the biomarker is CD44; b) determining the level of the biomarker in a control sample; and c) comparing the level of the biomarker in the biological sample from the subject to the level of the biomarker in the control sample; wherein a decreased level of the biomarker in the biological sample from the subject in comparison with the level of the biomarker in the control sample correlates with an increased responsiveness of the subject to the treatment.

[00214] In certain embodiments methods of monitoring the efficacy of a treatment of a disease, disorder, or condition in a subject treated with a treatment compound, comprise: a) obtaining a first biological sample from the subject; b) determining the level of a biomarker in the first biological sample, wherein the biomarker is CD 44, CD83 or combination thereof; c) administering the treatment compound to the subject; d) thereafter obtaining a second biological sample from the subject; e) determining the level of the biomarker in the second biological sample; and f) comparing the levels of the biomarker in the first and second biological samples; wherein the subject is responsive to the treatment if the level of the biomarker in the second biological sample of the subject is altered as compared to the level of the biomarker in the first biological sample of the subject.

[00215] In certain embodiments methods of monitoring the efficacy of a treatment of a disease, disorder, or condition in a subject treated with a treatment compound, comprise: a) obtaining a first biological sample from the subject; b) determining the level of a biomarker in the first biological sample, wherein the biomarker is CD83; c) administering the treatment compound to the subject; d) thereafter obtaining a second biological sample from the subject; e) determining the level of the biomarker in the second biological sample, and f) comparing the levels of the biomarker in the first and second biological samples; wherein the subject is responsive to the treatment if the level of the biomarker in the second biological sample of the subject is higher than the level of the biomarker in the first biological sample of the subject.

[00216] In certain embodiments methods of monitoring the efficacy of a treatment of a disease, disorder, or condition in a subject treated with a treatment compound, comprise: a) obtaining a first biological sample from the subject; b) determining the level of a biomarker in the first biological sample, wherein the biomarker is CD44; c) administering the treatment compound to the subject; d) thereafter obtaining a second biological sample from the subject; e) determining the level of the biomarker in the second biological sample, and f) comparing the levels of the biomarker in the first and second biological samples; wherein the subject is responsive to the treatment if the level of the biomarker in the second biological sample of the subject is lower than the level of the biomarker in the first biological sample of the subject.

[00217] In certain embodiments methods of monitoring the compliance of a subject with a treatment of a disease, disorder, or condition with a treatment compound, comprise: a) obtaining a biological sample from the subject; b) determining the level of a biomarker in the biological sample, wherein the biomarker is CD44, CD83 or combination thereof; and c) comparing the level of the biomarker with the level of the biomarker in a control untreated sample from the subject; wherein the change in the level of the biomarker in the biological sample in comparison with the level of the biomarker in the control sample indicates the compliance of the subject with the treatment.

[00218] In certain embodiments methods of monitoring the compliance of a subject with a treatment of a disease, disorder, or condition with a treatment compound, comprise: a) obtaining a biological sample from the subject; b) determining the level of a biomarker in the biological sample, wherein the biomarker is CD83; and c) comparing the level of the biomarker with the level of the biomarker in a control untreated sample from the subject; wherein an increased level of the biomarker in the biological sample in comparison with the level of the biomarker in the control sample indicates the compliance of the subject with the treatment.

[00219] In certain embodiments methods of monitoring the compliance of a subject with a treatment of a disease, disorder, or condition with a treatment compound, comprise: a) obtaining a biological sample from the subject; b) determining the level of a biomarker in the biological sample, wherein the biomarker is CD44; and c) comparing the level of the biomarker with the level of the biomarker in a control untreated sample from the subject; wherein a decreased level of the biomarker in the biological sample in comparison with the level of the biomarker in the control sample indicates the compliance of the subject with the treatment.

[00220] In certain embodiments the treatment compound is an immunomodulatory compound. In certain embodiments the treatment compound is 3-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-piperidine-2,6-dione hydrochloride, or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixtures thereof. In one embodiment, the compound is (*S*)-3-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-piperidine-2,6-dione, or a pharmaceutically acceptable salt, solvate, or hydrate thereof.

7.7 PHARMACEUTICAL COMPOSITIONS AND DOSAGE FORMS

[00221] Pharmaceutical compositions can be used in the preparation of individual, single unit dosage forms. Pharmaceutical compositions and dosage forms provided herein comprise a compound provided herein, or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, racemate, clathrate, or prodrug thereof. Pharmaceutical compositions and dosage forms can further comprise one or more excipients.

[00222] Pharmaceutical compositions and dosage forms provided herein can also comprise one or more additional active ingredients. Examples of optional second, or additional, active ingredients are disclosed above.

[00223] Single unit dosage forms provided herein are suitable for oral, mucosal (*e.g.*, nasal, sublingual, vaginal, buccal, or rectal), parenteral (*e.g.*, subcutaneous, intravenous, bolus injection, intramuscular, or intraarterial), topical (*e.g.*, eye drops or other ophthalmic preparations), transdermal or transcutaneous administration to a patient. Examples of dosage forms include, but are not limited to: tablets; caplets; capsules, such as soft elastic gelatin capsules; cachets; troches; lozenges; dispersions; suppositories; powders; aerosols (*e.g.*, nasal sprays or inhalers); gels; liquid dosage forms suitable for oral or mucosal administration to a patient, including suspensions (*e.g.*, aqueous or non-aqueous liquid suspensions, oil-in-water emulsions, or a water-in-oil liquid emulsions), solutions, and elixirs; liquid dosage forms suitable for parenteral administration to a patient; eye drops or other ophthalmic preparations suitable for topical administration; and sterile solids (*e.g.*, crystalline or amorphous solids) that can be reconstituted to provide liquid dosage forms suitable for parenteral administration to a patient.

[00224] The composition, shape, and type of dosage forms will typically vary depending on their use. For example, a dosage form used in the acute treatment of a disease may contain larger amounts of one or more of the active ingredients it comprises than a dosage form used in the chronic treatment of the same disease. Similarly, a parenteral dosage form may contain smaller amounts of one or more of the active ingredients it comprises than an oral dosage form used to treat the same disease. These and other ways in which specific dosage forms are used will vary from one another will be readily apparent to those skilled in the art. *See*, *e.g.*, *Remington's Pharmaceutical Sciences*, 20th ed., Mack Publishing, Easton PA (2000).

[00225] In one embodiment, pharmaceutical compositions and dosage forms comprise one or more excipients. Suitable excipients are well known to those skilled in the art of pharmacy, and non-limiting examples of suitable excipients are provided herein. Whether a particular excipient is suitable for incorporation into a pharmaceutical composition or dosage form depends on a variety of factors well known in the art including, but not limited to, the way in which the dosage form will be administered to a patient. For example, oral dosage forms such as tablets may contain excipients not suited for use in parenteral dosage forms. The suitability of a particular excipient may also depend on the specific active ingredients in the dosage form. For example, the decomposition of some active ingredients may be accelerated by some excipients such as lactose, or when exposed to water. Active ingredients that comprise primary or secondary amines are particularly susceptible to such accelerated decomposition. Consequently, provided are pharmaceutical compositions and dosage forms that contain little, if any, lactose other mono- or di-saccharides. As used herein, the term "lactose-free" means that the amount of lactose present, if any, is insufficient to substantially increase the degradation rate of an active ingredient.

[00226] Lactose-free compositions can comprise excipients that are well known in the art and are listed, for example, in the *U.S. Pharmacopeia* (USP) 25-NF20 (2002). In general, lactose-free compositions comprise active ingredients, a binder/filler, and a lubricant in pharmaceutically compatible and pharmaceutically acceptable amounts. In one embodiment, lactose-free dosage forms comprise active ingredients, microcrystalline cellulose, pre-gelatinized starch, and magnesium stearate.

[00227] Also provided are anhydrous pharmaceutical compositions and dosage forms comprising active ingredients, since water can facilitate the degradation of some compounds. For example, the addition of water (*e.g.*, 5%) is widely accepted in the pharmaceutical arts as a means of simulating long-term storage in order to determine characteristics such as shelf-life or the stability of formulations over time. *See*, *e.g.*, Jens T. Carstensen, *Drug Stability: Principles & Practice*, 2d. Ed., Marcel Dekker, NY, NY, 1995, pp. 379-80. In effect, water and heat accelerate the decomposition of some compounds. Thus, the effect of water on a formulation can be of great significance since moisture and/or humidity are commonly encountered during manufacture, handling, packaging, storage, shipment, and use of formulations.

[00228] Anhydrous pharmaceutical compositions and dosage forms can be prepared using anhydrous or low moisture containing ingredients and low moisture or low humidity conditions. Pharmaceutical compositions and dosage forms that comprise lactose and at least one active ingredient that comprises a primary or secondary amine are anhydrous if substantial contact with moisture and/or humidity during manufacturing, packaging, and/or storage is expected.

[00229] An anhydrous pharmaceutical composition should be prepared and stored such that its anhydrous nature is maintained. Accordingly, anhydrous compositions are, in one embodiment, packaged using materials known to prevent exposure to water such that they can be included in suitable formulary kits. Examples of suitable packaging include, but are not limited to, hermetically sealed foils, plastics, unit dose containers (*e.g.*, vials), blister packs, and strip packs.

[00230] Also provided are pharmaceutical compositions and dosage forms that comprise one or more compounds that reduce the rate by which an active ingredient will decompose. Such compounds, which are referred to herein as "stabilizers," include, but are not limited to, antioxidants such as ascorbic acid, pH buffers, or salt buffers.

[00231] Like the amounts and types of excipients, the amounts and specific types of active ingredients in a dosage form may differ depending on factors such as, but not limited to, the route by which it is to be administered to patients. In one embodiment, dosage forms comprise a compound provided herein in an amount of from about 0.10 to about 500 mg. In other embodiments, dosage forms comprise a compound provided herein in an amount of about 0.1, 1, 2, 5, 7.5, 10, 12.5, 15, 17.5, 20, 25, 50, 100, 150, 200, 250, 300, 350, 400, 450, or 500 mg.

[00232] In other embodiments, dosage forms comprise the second active ingredient in an amount of 1 to about 1000 mg, from about 5 to about 500 mg, from about 10 to about 350 mg, or from about 50 to about 200 mg. Of course, the specific amount of the second active agent will depend on the specific agent used, the diseases or disorders being treated or managed, and the amount(s) of a compound provided herein, and any optional additional active agents concurrently administered to the patient.

6.6.1 Oral Dosage Forms

[00233] Pharmaceutical compositions that are suitable for oral administration can be provided as discrete dosage forms, such as, but not limited to, tablets (*e.g.*, chewable tablets), caplets, capsules, and liquids (*e.g.*, flavored syrups). Such dosage forms contain predetermined amounts of active ingredients, and may be prepared by methods of pharmacy well known to those skilled in the art. *See generally*, *Remington's Pharmaceutical Sciences*, 20th ed., Mack Publishing, Easton PA (2000).

[00234] Oral dosage forms provided herein are prepared by combining the active ingredients in an intimate admixture with at least one excipient according to conventional pharmaceutical compounding techniques. Excipients can take a wide variety of forms depending on the form of preparation desired for administration. For example, excipients suitable for use in oral liquid or aerosol dosage forms include, but are not limited to, water, glycols, oils, alcohols, flavoring agents, preservatives, and coloring agents. Examples of excipients suitable for use in solid oral dosage forms (*e.g.*, powders, tablets, capsules, and caplets) include, but are not limited to, starches, sugars, micro-crystalline cellulose, diluents, granulating agents, lubricants, binders, and disintegrating agents.

[00235] In one embodiment, oral dosage forms are tablets or capsules, in which case solid excipients are employed. In another embodiment, tablets can be coated by standard aqueous or nonaqueous techniques. Such dosage forms can be prepared by any of the methods of pharmacy. In general, pharmaceutical compositions and dosage forms are prepared by uniformly and intimately admixing the active ingredients with liquid carriers, finely divided solid carriers, or both, and then shaping the product into the desired presentation if necessary.

[00236] For example, a tablet can be prepared by compression or molding. Compressed tablets can be prepared by compressing in a suitable machine the active ingredients in a free-flowing form such as powder or granules, optionally mixed with an excipient. Molded tablets can be made by molding in a suitable machine a mixture of the powdered compound moistened with an inert liquid diluent.

[00237] Examples of excipients that can be used in oral dosage forms provided herein include, but are not limited to, binders, fillers, disintegrants, and lubricants. Binders suitable for use in pharmaceutical compositions and dosage forms include, but are not limited to, corn starch, potato starch, or other starches, gelatin, natural and synthetic gums such as acacia, sodium alginate, alginic acid, other alginates, powdered tragacanth, guar gum, cellulose and its derivatives (*e.g.*, ethyl cellulose, cellulose acetate, carboxymethyl cellulose calcium, sodium carboxymethyl cellulose), polyvinyl pyrrolidone, methyl cellulose, pre-gelatinized starch, hydroxypropyl methyl cellulose, (*e.g.*, Nos. 2208, 2906, 2910), microcrystalline cellulose, and mixtures thereof.

[00238] Suitable forms of microcrystalline cellulose include, but are not limited to, the materials sold as AVICEL-PH-101, AVICEL-PH-103 AVICEL RC-581, AVICEL-PH-105 (available from FMC Corporation, American Viscose Division, Avicel Sales, Marcus Hook, PA), and mixtures thereof. An specific binder is a mixture of microcrystalline cellulose and sodium carboxymethyl cellulose sold as AVICEL RC-581. Suitable anhydrous or low moisture excipients or additives include AVICEL-PH-103™ and Starch 1500 LM.

[00239] Examples of fillers suitable for use in the pharmaceutical compositions and dosage forms provided herein include, but are not limited to, talc, calcium carbonate (*e.g.*, granules or powder), microcrystalline cellulose, powdered cellulose, dextrates, kaolin, mannitol, silicic acid, sorbitol, starch, pre-gelatinized starch, and mixtures thereof. The binder or filler in pharmaceutical compositions is, in one embodiment, present in from about 50 to about 99 weight percent of the pharmaceutical composition or dosage form.

[00240] Disintegrants may be used in the compositions to provide tablets that disintegrate when exposed to an aqueous environment. Tablets that contain too much disintegrant may disintegrate in storage, while those that contain too little may not disintegrate at a desired rate or under the desired conditions. Thus, a sufficient amount of disintegrant that is neither too much nor too little to detrimentally alter the release of the active ingredients may be used to form solid oral dosage forms. The amount of disintegrant used varies based upon the type of formulation, and is readily discernible to those of ordinary skill in the art. In one embodiment, pharmaceutical compositions comprise from about 0.5 to about 15 weight percent of disintegrant, or from about 1 to about 5 weight percent of disintegrant.

[00241] Disintegrants that can be used in pharmaceutical compositions and dosage forms include, but are not limited to, agar-agar, alginic acid, calcium carbonate, microcrystalline cellulose, croscarmellose sodium, crospovidone, polacrilin potassium, sodium starch glycolate, potato or tapioca starch, other starches, pre-gelatinized starch, other starches, clays, other algins, other celluloses, gums, and mixtures thereof.

[00242] Lubricants that can be used in pharmaceutical compositions and dosage forms include, but are not limited to, calcium stearate, magnesium stearate, mineral oil, light mineral oil, glycerin, sorbitol, mannitol, polyethylene glycol, other glycols, stearic acid, sodium lauryl sulfate, talc, hydrogenated vegetable oil (*e.g.*, peanut oil, cottonseed oil, sunflower oil, sesame oil, olive oil, corn oil, and soybean oil), zinc stearate, ethyl oleate, ethyl laureate, agar, and mixtures thereof. Additional lubricants include, for example, a syloid silica gel (AEROSIL200, manufactured by W.R. Grace Co. of Baltimore, MD), a coagulated aerosol of synthetic silica (marketed by Degussa Co. of Plano, TX), CAB-O-SIL (a pyrogenic silicon dioxide product sold by Cabot Co. of Boston, MA), and mixtures thereof. If used at all, lubricants may be used in an amount of less than about 1 weight percent of the pharmaceutical compositions or dosage forms into which they are incorporated.

[00243] In one embodiment, a solid oral dosage form comprises a compound provided herein, anhydrous lactose, microcrystalline cellulose, polyvinylpyrrolidone, stearic acid, colloidal anhydrous silica, and gelatin.

6.6.2 Controlled Release Dosage Forms

[00244] Active ingredients such as the compounds provided herein can be administered by controlled release means or by delivery devices that are well known to those of ordinary skill in the art. Examples include, but are not limited to, those described in U.S. Patent Nos.: 3,845,770; 3,916,899; 3,536,809; 3,598,123; and 4,008,719; 5,674,533; 5,059,595; 5,591,767; 5,120,548; 5,073,543; 5,639,476; 5,354,556; 5,639,480; 5,733,566; 5,739,108; 5,891,474; 5,922,356; 5,972,891; 5,980,945; 5,993,855; 6,045,830; 6,087,324; 6,113,943; 6,197,350; 6,248,363; 6,264,970; 6,267,981; 6,376,461; 6,419,961; 6,589,548; 6,613,358; 6,699,500 each of which is incorporated herein by reference. Such dosage forms can be used to provide slow or controlled release of one or more active ingredients using, for example, hydropropylmethyl cellulose, other polymer matrices, gels, permeable membranes, osmotic systems, multilayer coatings, microparticles, liposomes, microspheres, or a combination thereof to provide the desired release profile in varying proportions. Suitable controlled release formulations known to those of ordinary skill in the art, including those described herein, can be readily selected for use with the active ingredients provided herein. Thus, the compositions provided encompass single unit dosage forms suitable for oral administration such as, but not limited to, tablets, capsules, gelcaps, and caplets that are adapted for controlled release.

[00245] All controlled release pharmaceutical products have a common goal of improving drug therapy over that achieved by their non controlled counterparts. Ideally, the use of an optimally designed controlled release preparation in medical treatment is characterized by a minimum of drug substance being employed to cure or control the condition in a minimum amount of time. Advantages of controlled release formulations include extended activity of the drug, reduced dosage frequency, and increased subject compliance. In addition, controlled release formulations can be used to affect the time of onset of action or other characteristics, such as blood levels of the drug, and can thus affect the occurrence of side (e.g., adverse) effects.

[00246] Most controlled release formulations are designed to initially release an amount of drug (active ingredient) that promptly produces the desired therapeutic effect, and gradually and continually release of other amounts of drug to maintain this level of therapeutic or prophylactic effect over an extended period of time. In order to maintain this constant level of drug in the body, the drug must be released from the dosage form at a rate that will replace the amount of drug being metabolized and excreted from the body. Controlled release of an active ingredient can be stimulated by various conditions including, but not limited to, pH, temperature, enzymes, water, or other physiological conditions or compounds.

[00247] In certain embodiments, the drug may be administered using intravenous infusion, an implantable osmotic pump, a transdermal patch, liposomes, or other modes of administration. In one embodiment, a pump may be used (*see*, Sefton, *CRC Crit. Ref. Biomed. Eng.* 14:201 (1987); Buchwald *et al., Surgery* 88:507 (1980); Saudek *et al., N. Engl. J. Med.* 321:574 (1989)). In another embodiment, polymeric materials can be used. In yet another embodiment, a controlled release system can be placed in a subject at an appropriate site determined by a practitioner of skill, i.e., thus requiring only a fraction of the systemic dose (*see, e.g.*, Goodson, Medical Applications of Controlled Release, vol. 2, pp. 115-138 (1984)). Other controlled release systems are discussed in the review by Langer (*Science* 249:1527-1533 (1990)). The active ingredient can be dispersed in a solid inner matrix, e.g., polymethylmethacrylate, polybutylmethacrylate, plasticized or unplasticized polyvinylchloride, plasticized nylon, plasticized polyethyleneterephthalate, natural rubber, polyisoprene, polyisobutylene, polybutadiene, polyethylene, ethylene-vinylacetate copolymers, silicone rubbers, polydimethylsiloxanes, silicone carbonate copolymers, hydrophilic polymers such as hydrogels of esters of acrylic and methacrylic acid, collagen, cross-linked polyvinylalcohol and cross-linked partially hydrolyzed polyvinyl acetate, that is surrounded by an outer polymeric membrane, e.g., polyethylene, polypropylene, ethylene/propylene copolymers, ethylene/ethyl acrylate copolymers, ethylene/vinylacetate copolymers, silicone rubbers, polydimethyl siloxanes, neoprene rubber, chlorinated polyethylene, polyvinylchloride, vinylchloride copolymers with vinyl acetate, vinylidene chloride, ethylene and propylene, ionomer polyethylene terephthalate, butyl rubber epichlorohydrin rubbers, ethylene/vinyl alcohol copolymer, ethylene/vinyl acetate/vinyl alcohol terpolymer, and ethylene/vinyloxyethanol copolymer, that is insoluble in body fluids. The active ingredient then diffuses through the outer polymeric membrane in a release rate controlling step. The percentage of active ingredient in such parenteral compositions is highly dependent on the specific nature thereof, as well as the needs of the subject.

6.6.3 <u>Parenteral Dosage Forms</u>

[00248] Parenteral dosage forms can be administered to patients by various routes including, but not limited to, subcutaneous, intravenous (including bolus injection), intramuscular, and intraarterial. In some embodiments, administration of a parenteral dosage form bypasses patients' natural defenses against contaminants, and thus, in these embodiments, parenteral dosage forms are sterile or capable of being sterilized prior to administration to a patient. Examples of parenteral dosage forms include, but are not limited to, solutions ready for injection, dry products ready to be dissolved or suspended in a pharmaceutically acceptable vehicle for injection, suspensions ready for injection, and emulsions.

[00249] Suitable vehicles that can be used to provide parenteral dosage forms are well known to those skilled in the art. Examples include, but are not limited to: Water for Injection USP; aqueous vehicles such as, but not limited to, Sodium Chloride Injection, Ringer's Injection, Dextrose Injection, Dextrose and Sodium Chloride Injection, and Lactated Ringer's Injection; water-miscible vehicles such as, but not limited to, ethyl alcohol, polyethylene glycol, and polypropylene glycol; and non-aqueous vehicles such as, but not limited to, corn oil, cottonseed oil, peanut oil, sesame oil, ethyl oleate, isopropyl myristate, and benzyl benzoate.

[00250] Compounds that increase the solubility of one or more of the active ingredients disclosed herein can also be incorporated into the parenteral dosage forms. For example, cyclodextrin and its derivatives can be used to increase the solubility of a compound provided herein. *See, e.g.*, U.S. Patent No. 5,134,127, which is incorporated herein by reference.

6.6.4 Topical and Mucosal Dosage Forms

[00251] Topical and mucosal dosage forms provided herein include, but are not limited to, sprays, aerosols, solutions, emulsions, suspensions, eye drops or other ophthalmic preparations, or other forms known to one of skill in the art. *See, e.g.*, *Remington's Pharmaceutical Sciences*, 16th, 18th and 20th eds., Mack Publishing, Easton PA (1980, 1990 and 2000); and *Introduction to Pharmaceutical Dosage Forms*, 4th ed., Lea & Febiger, Philadelphia (1985). Dosage forms suitable for treating mucosal tissues within the oral cavity can be formulated as mouthwashes or as oral gels.

[00252] Suitable excipients (*e.g.*, carriers and diluents) and other materials that can be used to provide topical and mucosal dosage forms encompassed herein are well known to those skilled in the pharmaceutical arts, and depend on the particular tissue to which a given pharmaceutical composition or dosage form will be applied. In one embodiment, excipients include, but are not limited to, water, acetone, ethanol, ethylene glycol, propylene glycol, butane-1,3-diol, isopropyl myristate, isopropyl palmitate, mineral oil, and mixtures thereof to form solutions, emulsions or gels, which are non-toxic and pharmaceutically acceptable. Moisturizers or humectants can also be added to pharmaceutical compositions and dosage forms. Examples of additional ingredients are well known in the art. *See, e.g., Remington's Pharmaceutical Sciences*, 16^{th},18^{th} and 20^{th} eds., Mack Publishing, Easton PA (1980, 1990 and 2000).

[00253] The pH of a pharmaceutical composition or dosage form may also be adjusted to improve delivery of one or more active ingredients. Also, the polarity of a solvent carrier, its ionic strength, or tonicity can be adjusted to improve delivery. Compounds such as stearates can also be added to pharmaceutical compositions or dosage forms to alter the hydrophilicity or lipophilicity of one or more active ingredients so as to improve delivery. In other embodiments, stearates can serve as a lipid vehicle for the formulation, as an emulsifying agent or surfactant, or as a delivery-enhancing or penetration-enhancing agent. In other embodiments, salts, solvates, hydrates, prodrugs, clathrates, or stereoisomers of the active ingredients can be used to further adjust the properties of the resulting composition.

6.6.5 KITS

[00254] In one embodiment, active ingredients provided herein are not administered to a patient at the same time or by the same route of administration. In another embodiment, provided are kits which can simplify the administration of appropriate amounts of active ingredients.

[00255] In one embodiment, a kit comprises a dosage form of a compound provided herein. Kits can further comprise additional active ingredients such as other anti-inflammatory, immunomodulatory or immunosuppressant compounds, or a combination thereof. Examples of the additional active ingredients include, but are not limited to, those disclosed herein.

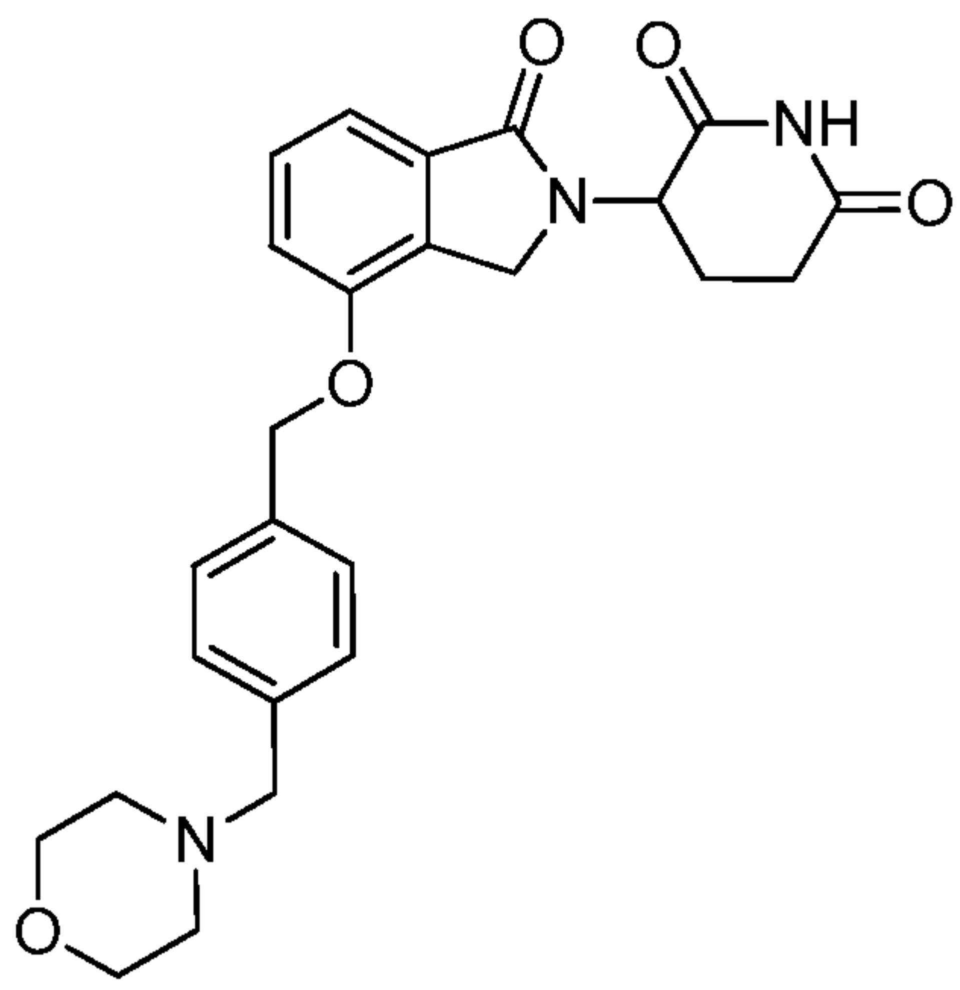
[00256] In other embodiments, kits can further comprise devices that are used to administer the active ingredients. Examples of such devices include, but are not limited to, syringes, drip bags, patches, and inhalers.

[00257] Kits can further comprise cells or blood for transplantation as well as pharmaceutically acceptable vehicles that can be used to administer one or more active ingredients. For example, if an active ingredient is provided in a solid form that must be reconstituted for parenteral administration, the kit can comprise a sealed container of a suitable vehicle in which the active ingredient can be dissolved to form a particulate-free sterile solution that is suitable for parenteral administration. Examples of pharmaceutically acceptable vehicles include, but are not limited to: Water for Injection USP; aqueous vehicles such as, but not limited to, Sodium Chloride Injection, Ringer's Injection, Dextrose Injection, Dextrose and Sodium Chloride Injection, and Lactated Ringer's Injection; water-miscible vehicles such as, but not limited to, ethyl alcohol, polyethylene glycol, and polypropylene glycol; and non-aqueous vehicles such as, but not limited to, corn oil, cottonseed oil, peanut oil, sesame oil, ethyl oleate, isopropyl myristate, and benzyl benzoate.

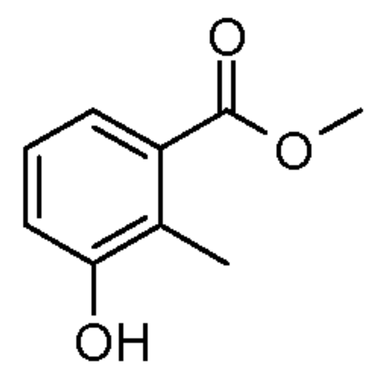
8. EXAMPLES

[00258] The following Examples are presented by way of illustration, not limitation. In the examples, test compound refers to (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

8.1 EXAMPLE 1: PREPARATION OF (*S*)-3-[4-(4-MORPHLIN-4-YLMETHYLBENZYLOXY)-1-OXO-1,3-DIHYDRO-ISOINDO-2-YL]PIPERIDINE-2,6-DIONE HYDROCHLORIDE



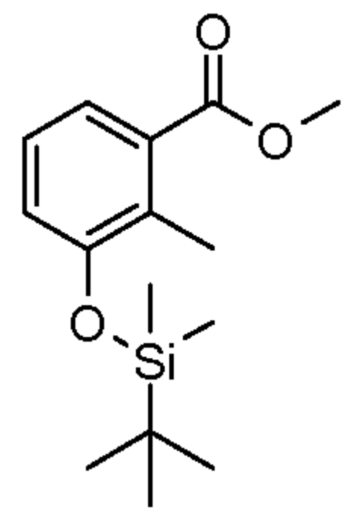
7.1.1 3-Hydroxy-2-methyl-benzoic acid methyl ester



[00259] 3-Hydroxy-2-methylbenzoic acid (105 g, 690 mmol) was added to MeOH (800 mL) in a 2L three neck round bottom flask equipped with condenser, thermometer and stirring bar followed by the addition of MeOH (250ml). H_2SO_4 (10 mL, 180 mmol) was added to above solution. The reaction mixture was stirred at 62°C for 17 hours. The solvent was removed in vacuo. The residue (200 mL) was added to water (600 mL) slowly at room temperature and a white solid was formed. The suspension was stirred in an ice bath for 30 minutes and filtered. The solid was washed with water (5 x 250 mL) and dried to give 3-hydroxy-2-methyl-benzoic acid methyl ester as a white solid

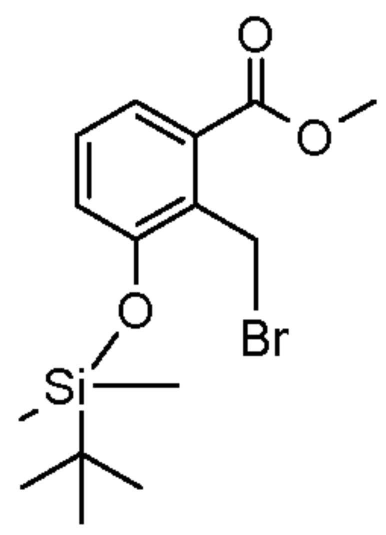
(100g, 87% yield). The compound was used in the next step without further purification: LCMS MH = 167; ^{1}H NMR (DMSO-d_6) δ 2.28 (s, 3H, CH_3), 3.80 (s, 3H, CH_3), 6.96 - 7.03 (m, 1H, Ar), 7.09 (t, J = 7.8 Hz, 1H, Ar), 7.14 - 7.24 (m, 1H, Ar), 9.71 (s, 1H, OH).

7.1.2 3-(tert-Butyl-dimethyl-silanyloxy)-2-methyl-benzoic acid methyl ester



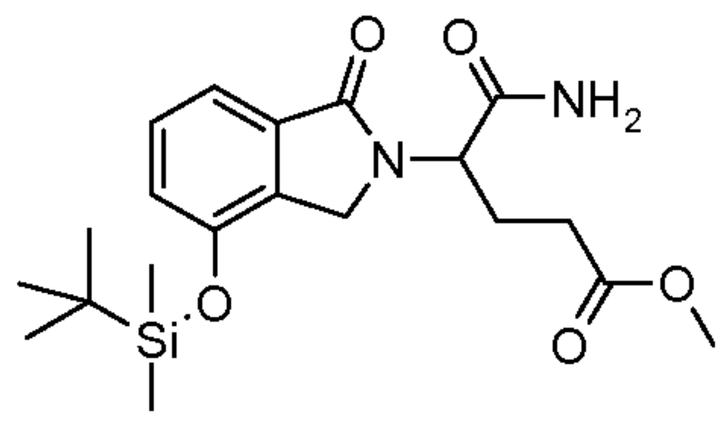
[00260] To a 1L three neck RB flask equipped with stirring bar and thermometer, were added DMF (300 mL), methyl 3-hydroxy-2-methylbenzoate (90 g, 542 mmol) and imidazole (92 g, 1,354 mmol). TBDMS-Cl (90 g, 596 mmol) was added to the above solution in portions to control the internal temp between 15-19°C over 20 minutes, and after addition, the internal temp dropped below 1 °C. The ice bath was removed and the reaction mixture was stirred at room temperature for 16 hours. The reaction mixture was added to ice water (500 mL), and the resulting solution was divided into two portions (700 mL x 2). Each portion was extracted with EtOAc (700 mL). Each organic layer was washed with cold water (350 mL) and brine (350 mL). Organic layers were combined and dried by $MgSO_4$. The combined organic layer was concentrated to give 3-(tert -butyl-dimethyl-silanyloxy)-2-methyl-benzoic acid methyl ester as a light brown oil (160 g, 100% crude yield). The compound was used in the next step without further purification: LCMS MH = 281; ^{1}H NMR (DMSO-d_6) δ -0.21 (s, 6H, CH_3, CH_3), 0.73 - 0.84 (m, 9H, CH_3, CH_3, CH_3), 2.10 (s, 3H, CH_3), 3.60 (s, 3H, CH_3), 6.82 (dd, 1H, Ar), 6.97 (t, J = 7.9 Hz, 1H, Ar), 7.13 (dd, J = 1.1, 7.7 Hz, 1H, Ar).

7.1.3 2-Bromomethyl-3-(tert-butyl-dimethyl-silanyloxy)-benzoic acid methyl ester



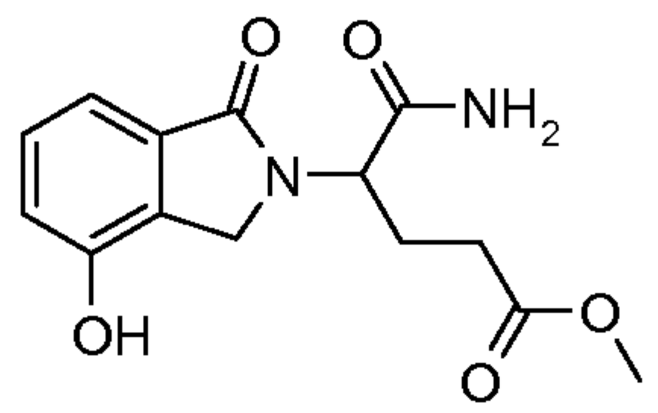
[00261] NBS (49.8 g, 280 mmol) was added to methyl 3-(tert-butyl dimethylsilyloxy)-2-methylbenzoate (78.4 g, 280 mmol) in methyl acetate (500 mL) at room temperature to give an orange colored suspension. The resulting reaction mixture was heated in an oil bath at 40°C and shined by 300 wt sunlight bulb at reflux for 4 hours. The reaction mixture was cooled down and washed by Na_2SO_3 solution (2 x 600 mL, 50% saturated concentration), water (500 mL) and brine (600 mL). The organic layer was dried by $MgSO_4$ and decolorized by charcoal. The organic layer was concentrated to give 2-bromomethyl-3-(tert -butyl-dimethyl-silanyloxy)-benzoic acid methyl ester as a light brown oil (96 g, 91% crude yield). The compound was used in the next step without further purification: LCMS M-Br = 279; ^{1}H NMR (DMSO-d_6) δ 0.05 - 0.11 (m, 6H, CH_3, CH_3), 0.82 (s, 9H, CH_3, CH_3, CH_3), 3.65 (s, 3H, CH_3), 4.74 (s, 2H, CH_2), 6.94 (dd, J = 1.3, 8.1 Hz, 1H, Ar), 7.10 - 7.20 (m, 1H, Ar), 7.21 - 7.29 (m, 1H, Ar).

7.1.4 4-Carbamoyl-butyric acid methyl ester



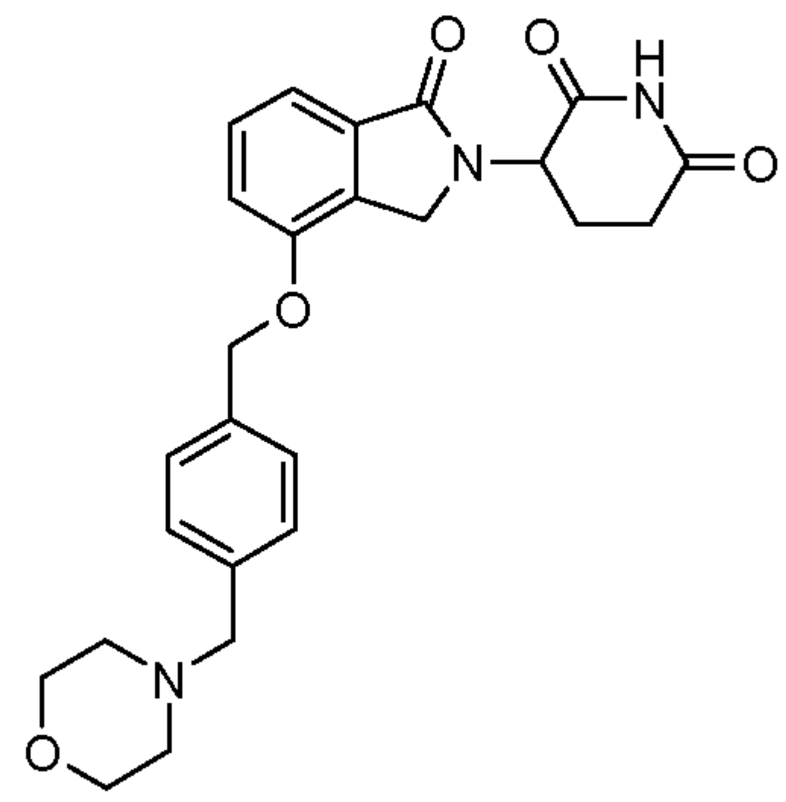
[00262] To a stirred solution of methyl 2-(bromomethyl)-3-(tert -butyldimethylsilyloxy)benzoate (137.5 g, 325 mmol) in acetonitrile (1100 mL) in a 2 L round bottom flask, was added methyl 4,5-diamino-5-oxopentanoate hydrochloride (70.4 g, 358 mmol). To the suspension was added DIPEA (119 ml, 683 mmol) through an addition funnel over 10 minutes and the suspension was stirred at room temperature for 1 hour before the mixture was heated in an oil bath at 40°C for 23 hours. The reaction mixture was concentrated under vacuo. The residue was stirred in ether (600 mL), and a white solid precipitated out. The mixture was filtered and the solid was washed with ether (400 mL). The filtrate was washed with HCl (1N, 200 mL), $NaHCO_3$ (sat. 200 mL) and brine (250 mL). The aqueous acid layer and basic layer were kept separately. Then the solid was further washed with ether (250 mL) and the liquid was washed with above acid solution and basic solution. The two organic layers were combined and concentrated under vacuo to give 4-[4-(tert -Butyl-dimethyl-silanyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-4-carbamoyl-butyric acid methyl ester as a brown oil (152g, 115% crude yield, 77% purity by H NMR). The compound was used in the next step without further purification: LCMS MH = 407.

7.1.5 4-Carbamoyl-4-(4-hydroxy-1-oxo-1,3-dihydro-isoindol-2-yl)-butyric acid methyl ester



[00263] To a stirred cold solution of methyl 5-amino-4-(4-(tert-butyldimethylsilyloxy)-1-oxoisoindolin-2-yl)-5-oxopentanoate (152 g, 288 mmol) in DMF (500 mL) and water (55 mL), was added by K_2CO_3 (19.89 g, 144 mmol) by portions over 5 minutes. The resulting reaction mixture was stirred at room temperature for 40 minutes. The reaction mixture was cooled in an ice bath. To the mixture, HCl (12M, 23.99 ml, 288 mmol) was added slowly. After the addition, acetonitrile (280 mL) was added to the mixture and a solid precipitated out. The mixture was stirred at room temperature for 10 minutes and filtered. The solid was washed with acetonitrile (50 mL x 4). The filtrate was concentrated under high vacuo to give a yellow oil (168 g). The oil was dissolved in acetonitrile (600 mL) and stirred at room temperature for 10minutes. The mixture was filtered and the solid was washed with acetonitrile (25 mL x 2). The filtrate was concentrated under high vacuo to give a yellow oil (169g), which was added to a mixture of water (1200 mL) and ether (1000 mL). The mixture was stirred for 3 minutes and the layers were separated. The aqueous solution was concentrated under high vacuo and the residue was stirred in acetonitrile (160 mL) and a white solid was formed after overnight stirring. The mixture was filtered to give 4-carbamoyl-4-(4-hydroxy-1-oxo-1,3-dihydro-isoindol-2-yl)-butyric acid methyl ester as a white solid (46 g, 54% yield). The filtrate was concentrated and the residue was further crystallized in acetonitrile (60 mL) to give more 4-carbamoyl-4-(4-hydroxy-1-oxo-1,3-dihydro-isoindol-2-yl)-butyric acid methyl ester as a white solid(11.7 g, 14% yield). The filtrate was concentrated and the residue was purified by ISCO chromatography to give more 4-carbamoyl-4-(4-hydroxy-1-oxo-1,3-dihydro-isoindol -2-yl)-butyric acid methyl ester as a white solid (13.2 g, 15% yield). The total product obtained was 70.9 g in 83% yield: LCMS MH = 293; ^{1}H NMR (DMSO-d_6) δ 1.95 - 2.34 (m, 4H, CH_2, CH_2), 3.51 (s, 3H, CH_3), 4.32 (d, J = 17.6 Hz, 1H, CHH), 4.49 (d, J = 17.4 Hz, 1H, CHH), 4.73 (dd, J = 4.7, 10.2 Hz, 1H, CHH), 6.99 (dd, J = 0.8, 7.9 Hz, 1H, Ar), 7.10 - 7.23 (m, 2H, Ar, NHH), 7.25 - 7.38 (m, 1H, Ar), 7.58 (s, 1H, NHH), 10.04 (s, 1H, OH).

7.1.6 3-(4-((4-(morpholinomethyl)benzyl)oxy)-1-oxoisoindolin-2-yl)piperidine-2,6-dione



[00264] Step 1: To the solution of 3-(4-hydroxy-1-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione (2.5g, 8.56 mmol) in THF (60 mL) was added triphenyl phosphine (polymer supported 1.6mmol/g, 12 g, 18.8 mmol). The mixture was stirred at room temperature for 15 minutes. Diisopropyl azodicarboxylate (3.96 mL, 18.8 mmol) was added at 0°C, and the mixture was stirred at 0°C for 30 minutes. (4-Morpholin-4-ylmethyl-phenyl)-methanol (2.62 g,12.4 mmol) was added at 0°C, and the mixture was allowed to warm to room temperature and stirred at room temperature overnight. The reaction mixture was filtered, and the filtrate was concentrated. The resulting oil was purified on silica gel column eluted with methylene chloride and methanol (gradient, product came out at 6% methanol) to give 4-carbamoyl-4-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-butyric acid methyl ester (2.2 g, 54% yield). The product was used in the next step without further purification.

[00265] Step 2: To the THF solution (50 mL) of 4-carbamoyl-4-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-butyric acid methyl ester (2.2g, 4.57 mmol) was added potassium tert-butoxide (0.51 g, 4.57 mmol) at 0°C. The mixture was stirred at 0°C for 10 minutes and was quenched with 1N HCl (5 mL, 5mmol) followed by saturated $NaHCO_3$ (25 mL). The mixture was extracted with EtOAc (2 X 50 mL). The organic layer was washed with water (30 mL), brine (30 mL), dried over $MgSO_4$ and concentrated. To the resulting solid was added EtOAc (10 mL) followed by hexane (10 mL) under stirring. The suspension was filtered to give 3-(4-((4-(morpholinomethyl)benzyl)oxy)-1-oxoisoindolin-2-yl)piperidine-2,6-dione as white solid (1.5g, 73% yield). HPLC: Waters Symmetry C_{18}, 5μm, 3.9 x 150 mm, 1 mL/min, 240 nm, gradient to 95/5 acetonitrile/0.1% H_3PO_4 in 5 min,: t_R = 4.78 min (97.5%); mp: 210-212 °C; ^{1}H NMR (DMSO-d_6) δ 1.86 - 2.09 (m, 1H, CHH), 2.29 - 2.38 (m, 4H, CH_2,CH_2), 2.44 (dd, J = 4.3, 13.0 Hz, 1H, CHH), 2.53 - 2.64 (m, 1H, CHH), 2.82 - 2.99 (m, 1H, CHH), 3.46 (s, 2H, CH_2), 3.52 - 3.61 (m, 4H, CH_2,CH_2), 4.18 - 4.51 (m, 2H, CH_2), 5.11 (dd, J = 5.0, 13.3 Hz, 1H, NCH), 5.22 (s, 2H, CH_2), 7.27 - 7.38 (m, 5H, Ar), 7.40 - 7.53 (m, 3H, Ar), 10.98 (s, 1H, NH) ^{13}C NMR (DMSO-d_6) δ 22.36, 31.21, 45.09, 51.58, 53.14, 62.10, 66.17, 69.41, 114.97, 115.23, 127.64, 128.99, 129.81, 129.95, 133.31, 135.29, 137.68, 153.50, 168.01, 170.98, 172.83; LCMS: 465; Anal Calcd for $C_{25}H_{27}N_3O_5$ + 0.86 H_2O: C, 64.58; H, 6.23; N, 9.04; Found: C, 64.77; H, 6.24; N, 8.88.

[00266] (*S*)-3-(4-((4-(morpholinomethyl)benzyl)oxy)-1-oxoisoindolin-2-yl)piperidine-2,6-dione and (*R*)-3-(4-((4-(morpholinomethyl)benzyl)oxy)-1-oxoisoindolin-2-yl)piperidine-2,6-dione were prepared from 3-(4-((4-(morpholinomethyl)benzyl)oxy)-1-oxoisoindolin-2-yl)piperidine-2,6-dione through chiral separation.

8.2 EXAMPLE 2: EFFECT ON THE EXPRESSION OF TRANSCRIPTION FACTORS IN PRIMARY HUMAN B CELL DIFFERENTIATION MODEL

[00267] In this example, the effect of (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione (test compound) on the expression of transcription factors controlling plasma cell differentiation, and immunoglobulin production, using an *in vitro* human B-cell differentiation culture system.

[00268] The following abbreviations are used in this example:

Abbreviation or Specialist Term	Explanation or Definition
BCL6	B-cell lymphoma 6 protein
BLIMP-1	B-lymphocyte-induced maturation protein 1
EtOH	Ethanol
FBS	Fetal bovine serum
DMSO	Dimethyl sulfoxide
IRF-4	Interferon regulatory factor 4
MFI	Mean fluorescence intensity
PAX5	Paired box protein Pax-5
SLE	Systemic lupus erythematosus
XBP-1	X-box binding protein 1

[00269] 50 ml Buffy coat from healthy donors were obtained from Blood Center of New Jersey. SLE Lupus PBMC samples were obtained from Conversant Bio (Huntsville, Alabama 35806).

[00270] The following cell culture reagents were used in this study.

ITEM	Source
Iscoves Modified Dulbecco medium	Invitrogen
Fetal Bovine Serum	Lonza
Human Insulin	Sigma
Human Transferrin	Sigma
penicillin/ streptomycin	Lonza
Recombinant Human IL-2	R & D Systems
Recombinant Human IL-6	R & D Systems
Recombinant Human IL-10	R & D Systems
Recombinant Human IL-15	R & D Systems
CD40 Ligand/TNFSF5/ histidine-tagged	R & D Systems
polyHistidine mouse IgG1 antibody	R & D Systems
ODN 2006- Human TLR9 ligand	Invivogen
Human Interferon ALPHA A	PB interferon source

[00271] The following were used in flow cytometry analysis.

ITEM	Source
FITC anti-human CD19	IBD Pharmigen
FITC anti-human CD20	IBD Pharmigen
PE anti-human CD27	IBD Pharmigen
PE anti-human CD38	IBD Pharmigen
APC anti-human CD38	IBD Pharmigen
FITC anti-mouse IgG1k Isotype	IBD Pharmigen
PE anti-mouse IgG1k Isotype	IBD Pharmigen
FITC anti-mouse IgG2bk Isotype	IBD Pharmigen
APC anti-mouse IgG1k Isotype	IBD Pharmigen
Stain Buffer	IBD Pharmigen

[00272] The following gene primers were used for RT-PCR:

ITEM	Source
AICDA gene expression assay	Applied Biosystem
BCL6 gene expression assay	Applied Biosystem
GAPDH gene expression assay	Applied Biosystem

IGJ gene expression assay	Applied Biosystem
IRF4 gene expression assay	Applied Biosystem
PAX5 gene expression assay	Applied Biosystem
PRDM1 gene expression assay	Applied Biosystem
XBP1 gene expression assay	Applied Biosystem
Reverse Transcription Kit	Applied Biosystem
Master Mix	Applied Biosystem

7.2.1 Purification of hPBMCs

[00273] Fifty ml human buffy coat was aliquoted 25 ml each into two 50 ml conical tubes and 25 ml sterile HBSS was added to each conical tube. The tubes were gently mixed by inverting. Fifteen ml of room temperature Ficoll-Paque Plus (GE Healthcare; cat# 17-1440-02) was aliquoted into four 50 ml conical tubes. Then 25 ml of the Buffy coat/HBSS mixture was layered gently and slowly on top of the Ficoll. The samples were centrifuged at 450 rpm for 35 minutes. The top layered containing plasma was pipetted off and discarded. The interface containing mononuclear cells was transferred into two 50 ml conical tubes. Both conical tubes were filled to total volume of 50 ml with HBSS and centrifuged at 1200 rpm for 10 minutes. The cells were washed again in HBSS and spun at 1000 rpm for 10 minutes. Cell pellet was resuspended with 20 mL of B cell media (Iscoves +10% PFBS, 1% P/S, and 5 μg/mL human insulin) and counted on the cell counter.

7.2.2 B Cell Enrichment CD19+

[00274] Purified PBMCs were counted and aliquoted at $2x10^8$ cells per tube. The cells were centrifuged at 1200 rpm for 5 minutes and then supernatants were discarded. The cells were resuspended in 4 mL of Robosep Buffer (Stemcell Technologies catalog # 20104) and transferred to a 14 mL polystyrene round bottom tube (BD catalog # 352057) and mixed well. Then 200 μL of EasySep Human B cell enrichment cocktail was added (StemCell Technologies catalog # 19054). Samples were vortexed and incubated at room temperature for 10 minutes. Next 300 μL of EasySep Magnetic particles (vortexed) (StemCell Technologies catalog # 19054) were added to the tube. Samples were vortexed and incubated at room temperature for 5 minutes. After the 5 minute incubation, 5 mL of Robosep buffer was added to the tube and mixed well by pipetting up and down. The tube was immediately places in the silver magnet (StemCell Technologies catalog # 19054) and incubated at room temperature for 5 minutes. After incubation, in one continuous motion, invert magnet and tube and pour off desired fraction into a 50 mL conical. . These procedures were repeated for remaining PBMCs (per one donor) and combined. The combined fraction was centrifuged at 1200 rpm for 5 minutes and then supernatants were discarded and cells were resuspended in 5 mL of B cell media. The isolated CD19+ cells were counted on the cell counter.

7.2.3 B cell Differentiation Assay

[00275] Step 1 -B cell Activation- day 0 through day 4: Prepare fresh B cell cocktail by adding 50 μg/mL of human transferrin to B cell media. (Iscoves +10% PFBS, 1% P/S, and 5 μg/mL human insulin). Filter required volume of media needed for experiment through a 0.22 μM filter. Add B cell differentiation cocktail (final concentration): recombinant human IL-2 (20U/mL), IL-10 (50 ng/mL), IL-15 (10 ng/mL), CD40 Ligand/TNFSF5/ histidine-tagged (50 ng/mL), polyHistidine mouse IgG1 antibody (5 μg/mL), and ODN 2006- Human TLR9 ligand (10 μg/mL) to cells. Five milliliters ($1x10^5$/ml) of CD19+ B cell were added to each well of a 6 well flat-bottom plate (final cell count = $5x10^5$/well). Five μL (1x) ± compound/DMSO was added to each test well (0.1% final DMSO) and incubated at 37°C for 4 days.

[00276] Step 2 –Plasmablast Generation- day 4 through day 7: Cells were harvested and counted on the cell counter; an aliquot was removed for flow analysis, the remaining cells were washed with PBS. Prepare fresh B cell cocktail by adding 1μg/ml of human transferrin to B cell media. (Iscoves +10% PFBS, 1% P/S, and 5 μg/mL human insulin). Filter required volume of media needed for experiment through a 0.22 μM filter. Add B cell differentiation cocktail (final concentration): recombinant human IL-2 (20U/mL), IL-10 (50 ng/mL), IL-15 (10 ng/mL), IL-6 (50ng/mL) to cells. Add fresh B cell cocktail and transfer cells back to the original wells and bring volume back to 5 mL. Five μL (1x) ± compound/DMSO was added to each test well (0.1% final DMSO) and incubated at 37°C for 4 days.

[00277] On day 7, cells were harvested and counted on the cell counter. Cells were then divided for flow analysis and the remaining cells were lysed with RLTbuffer and stored at -80°C for RNA extraction and gene expression. Supernatants were aliquoted and frozen at -20°C for immunoglobulin assays.

7.2.4 Preparation of Test Compound Stock Solutions and Dilutions

[00278] The test compounds was weighed and dissolved in sterile 100% DMSO (dimethyl sulfoxide; Research Organics, Cleveland, OH) to create 40 mM stock solution. Dilutions of the 40 mM stock were used in the assay to obtain final test compound concentrations based on experimental design.

7.2.5 RNA Extraction and Gene Expression

[00279] Differentiated B cells (see paragraphs [00226]-[00227]) were harvested for total ribonucleic acid (RNA) preparation with a Qiacube RNA extraction instrument (Qiagen, Valencia, CA) using QIAGEN RNeasy mini spin-column kits. Purified RNA was reverse transcribed into cDNA with thermal cycler [MJ Research; Inc., St. Bruno, Quebec, Canada) using a reverse-transcriptase kit (Applied Biosystems). The gene expression assay was carried out using 7500 RT-PCR system (Applied Biosystems) in triplicate. A glyceraldehyde 3-phosphate dehydrogenase gene expression assay control was run for each sample and used as a normalization control. For each gene, samples within each experiment were normalized to 0.1% DMSO treatment only for that particular time point.

[00280] Supernatants (from paragraph [00228]) were harvested and analyzed by ELISA for IgG and IgM production (ZeptoMetrix Corp. Buffalo, NY).

7.2.6 Cell Phenotyping

[00281] Differentiated B cells (see paragraphs [00226]-[00227]) were harvested, counted, and aliquoted at about $1x10^6$ cells or less per 4 mL tube. The cells were washed 1X with stain buffer. Next, the cells then were blocked with 10% human serum/PBS for 20-30 minutes. Following blocking, the cells were centrifuged for 5 minutes at 1200 rpm and supernatants discarded. In the 100 μL of remaining buffer, 20 μL of various BD Pharmigen flow antibodies were added according to experimental design. The cells were stained for 20-30 minutes at 4°C. Then the cells were washed 2X with stain buffer and supernatants discarded. Next, 500 μL of stain buffer or PBS was added to the tubes. The samples were immediately analyzed or put at 4°C overnight. Cells were stained with mouse anti-human CD20 and CD38, CD19 and CD27, or respective isotype controls. All samples were analyzed using a FACSCanto flow cytometer, FACSDiva analysis software (BD Bioscience), and FlowJo Analysis software.

7.2.7 Cell Viability Analysis

[00282] To determine live cell count, B cells (see paragraphs [00226]-[00227]) were stained with 0.4% trypan blue and live cells counted using the Countess automated cell counter (Invitrogen) in duplicate samples.

[00283] The data was graphed using GraphPad Prism 5.0 software. IC_{50} values were calculated using non-linear regression, sigmoidal-dose response constraining the top to 100% and bottom to 0% allowing for a variable slope. The results for test compounds in the Ig assays were expressed as the percentage inhibition relative to control DMSO values.

[00284] The test compound dose-dependently reduced the percentage of CD20-CD38+ plasmablasts, and increased the percentage of CD20+CD38- activated B cells. The plasmablast population (quadrant 1) was 30.4% in the DMSO control at day 7, and the test compound reduced the population to 27.3% at 2 nM, 2.1% at 20 nM, and 0.4% at 200nM (FIG. 1). The test compound reduced B cell viability during the first 4 days of culture (FIG. 2). The effect of the test compound on B and plasma cell transcription factor expression is depicted in FIG. 3. The effect of the test compound on IgG production in plasmablast cultures is depicted in FIG. 4.

[00285] The test compound dose-dependently inhibited expression of plasma cell transcription factors IRF4, BLIMP1, and XBP1 significantly. The test compound enhanced B cell transcription factor PAX5. The effect of the test compound on B and plasma cell transcription factor expression is depicted in FIG. 5A and 5B.

[00286] The test compound, pomalidomide, and lenalidomide inhibit IgG production with IC_{50} of 0.0018 μM, 0.049 μM, and 0.32 μM, respectively. The data indicated that the test compound is 27-fold more potent than pomalidomide at inhibiting IgG production during plasmablast differentiation. The effect of the test compound on IgG production in B cell cultures on days 4, 7 and 10 is depicted in FIG. 6. The effect of the test compound, alone and in combination with prednisolone, on IgG production by *in vitro*-differentiated plasma blasts/plasma cells is depicted in FIG. 7. The effect of the test compound on CD20/CD38 expression during B cell differentiation at day 7 is depicted in FIG. 8. The effect of the test compound on cell viability during plasmablast differentiation is depicted in FIG. 9.

[00287] In peripheral blood mononuclear cell isolated by patients with systemic lupus erythematosus (SLE), the test compound inhibited IgG and IgM production with IC_{50}s of 3.2 nM and 0.9 nM, respectively. These findings indicated that the test compound has the potential to inhibit B cell differentiation to the plasma cell lineage, and suggested that the test compound may be useful in the treatment of autoimmune disorders such as SLE, which are characterized by the overproduction of autoantibodies. The effect of the test compound on B cell differentiation and function in SLE patient PBMC cells is depicted in FIG. 10. The effect of the test compound on IgG and IgM productions in normal and SLE patient PBMC cells is depicted in Table 1.

[00288] FIGs. 11A and 11B depict the effect of the test compound on human IgG and IgM production, respectively, in B cell cultures on day 7.

[00289] **Table 1**. Potency for Inhibition of Normal and SLE PBMC Production of IgG and IgM

	IgG IC_{50} (nM)		IgM IC_{50} (nM)	
	SLE (n=3)	Normal (n=3)	SLE (n=3)	Normal (n=3)
Test Compound	3.2	2.1	0.9	0.35
pomalidomide	19	63	3.8	17
apremilast	>10,000	>10,000	>10,000	>10,000

8.3 EXAMPLE 3: B CELL DIFFERENTIATION ASSAY USING FLOW CYTOMETRY AND LASER SCANNING CYTOMETRY

[00290] Cell Culture Materials: Enriched normal B cells and SLE patient peripheral blood mononuclear cells (PBMC) were cultured in the *in vitro* B cell differentiation system with IMDM medium (Invitrogen) and 10% FCS, supplemented with human transferrin and human insulin (Sigma) plus cytokine cocktail. Test compound was added to culture on day 0 and day 4.

[00291] B Cell Differentiation Protocol: Enriched B cells were isolated from fresh buffy-coat (leukocyte enriched units) by Ficoll-Hypaque density gradient centrifugation followed by incubation with EasySep negative selection human B cell enrichment kit (Stem cell technologies). In brief, 2 x 10^8 /ml PBMC were mixed with 4 ml of Robosep buffer and transfered to a 14 mL polystyrene round bottom tube. EasySep Human B cell enrichment cocktail (200 μL) was added per tube, vortexed and incubated at room temperature for 10 minutes. EasySep Magnetic particles were added (300 μL per tube) and vortexed and incubated at room temperature for 5 minutes. Robosep buffer (5 mL) was added to each tube and mixed well by pipetting up and down. Tubes were placed in the silver magnet and incubated at room temperature for 5 minutes. The magnet and tube were picked up and in one continuous motion inverted, pouring off the desired fraction into a 50 mL conical. Cells were spun at 1200 rpm for 5 minutes. Supernatant was poured off and 5 mL of fresh B cell media added. After cells were counted, an aliquot was removed for FACS analysis and the remaining cells were used for culture. CD19+ B cells were isolated to ~95% purity as determined by flow cytometry. Purified B cells were plated at 1 x 10^5 cell/ml in a sterile 6 well plate at 5ml per well. All cell cultures were performed in IMDM medium (Invitrogen) and 10% FCS, supplemented with human transferrin and human insulin (Sigma). B-cell activation, PB generation and PC generation were performed based on the modified in vitro system of differentiation of B cells into plasma cells. All recombinant human cytokines IL-2, IL-4, IL-6, IL-10, IL-15, INF-α, and CD40L and anti-polyhistidine mAb were added at indicated culture steps. Various concentrations of test compound (2, 20 and 200 nM) were added to culture on day 0 and day 4. On day4, pool all cells together from same treatment, count cells, remove cells for FACS analysis and cytospin preparation. Plate the remaining cells at 2.5 x 10^5 cell/ml in a sterile 6 well plate at 5ml per well. SLE PBMCs were cultured for 7 days under conditions to promote plasma cell differentiation as normal B cells.

[00292] Immunophenotyping For Flow Cytometric Analysis: Cells were stained using multicolor direct immunofluorescence stain for flow cytometric analysis. Surface staining was performed before cell fixation and permeabilization. Cells (50 µl; 1 x 10^6 cells/ml in washing buffer, 2% FBS with 0.1% NaN3 in PBS) were used for each staining. The cells were stained with isotype control mAb (1 µg/10^6 cells) and multicolor FITC–conjugated anti-CD20 mAb and PE–conjugated anti-CD38 mAb, or PerCP-Cy5.5 conjugated anti-CD44 mAb, PE-conjugated anti-CD83 mAb were used for day 4 activated B cells (CD20+CD38- cells), and day 4 PBs and day 7 PBs (CD20-CD38+), and other staining, analyzed by flow cytometry as per manufacturer's instructions. The intracellular staining of transcription factor proteins (BCL-6, IRF-4, BLIMP-1, PAX-5 and XBP-1) and IgJ was performed according to the manufacturer's recommendations. Flow cytometric analysis was performed with a FACSCanto using FACSDiva 6 (BD Biosciences). For data analysis, Flowjo (Tree Star) software was used.

[00293] Preparation Of Cytospin From Single Cell Suspension And Immunofluorescence Staining for iCyte: A cell suspension of not more than 0.5 x 10^6 cells/ml of 2% FBS-containing PBS was prepared. Up to 200 µl of this suspension was loaded in each cuvette and spinned at 800 rpm for 3 min. The cuvette and the paper were carefully detached without damaging the fresh cytospin and proceeded with either immediate fixation or drying. Unfixed cytospins were stored for max 2 days at room temperature. Cells on slides were fixed with increasing concentrations of EtOH and allowed to dry prior to staining. After blocking non-specific binding with normal serum (species same as secondary antibody), sections were incubated with the mixture of following monoclonal antibodies in a humidified chamber at cool room for overnight: (i) anti-human CD38 as plasmablast cell marker, and (ii) anti-BCL-6, IRF-4, BLIMP-1, PAX5 and XBP-1 for transcription factor proteins. After washings, slides were incubated for 1 hr at room temperature in dark with the mixture of secondary antibodies which were raised in different species (with two different fluorochromes, *i.e.*, Alexa Fluor-488 and Alexa Fluor-633). The slides were then rinsed in PBS, counterstained with DAPI for 20 minutes at room temperature, coverslipped with anti-fade fluorescent mounting medium, and sealed with nail polish. The slides were stored in dark at 4 °C. To exclude false positives produced by nonspecific binding of the secondary antibody, all of the tissues were treated in the same manner with buffer substituting for the primary antibody. The color of the antibody staining was observed and quantity was analyzed in the tissue sections using iCyte.

[00294] Laser Scanning Cytometer Image Capturing And Fluorescence Quantitative Analysis: Dual-color immunofluorescence stain was performed on cells which were cytospined on slides (Cytospin 4, Thermo scientific) based on standard IHC method. Image capturing and fluorescence quantitative analysis were performed using a laser scanning cytometry (iCys quantitative imaging cytometry, CompuCyte). Two passes were set up (first pass for 488 and second pass for 405/633). Low resolution scan was used for mosaic scan, and high resolution scan for region scan and analysis. In brief, the slide was placed on the LSC stage and a region selected for scanning. The LSC utilized the argon laser operating at 5 mW. The slide was scanned using the 20X objective. Cells were identified and selected by contouring on blue fluorescence and a minimum cell size, as determined by DAPI staining. The cell detection threshold was set to select single cells based on forward angle light scatter displayed in a dot plot of cell area vs. forward scatter integral. Laser light-scatter events were captured and used to contour single cells within the scan data display. Contour discrimination was set from the nuclear portion of the scanned cell such that about 67% of the total light scatter pixelation was contoured. Green and long red PMT-detector gain voltages are set so that no greater than 75% maximum saturation of the max pixel in the respective fields is achieved during the scan. After establishing the scan area, the slide was analyzed using a 40X objective. A minimum of 6 scanning areas for each slide was examined. A cell gallery was created by relocation of cells from each of the major peaks in the histogram of integrated long red fluorescence. The morphologic composition of relocated cells was examined for purposes of quality assurance. Data can be analyzed in either integrated log fluorescence mode or in linear max pixel mode. Different cell population in LSC scanning was scored as percentage and MFI, and quantitative comparison to DMSO controls.

[00295] Data Analysis: Flow cytometry surface and intracellular molecules were analyzed by FACSCanto. Data analysis was done by Flowjo. The color of the antibody staining was observed and quantity was analyzed in the tissue sections using iCyte. Different cell population in FCM and LSC scanning was scored as percentage and MFI, and quantitative comparison to DMSO controls. The data was expressed as Mean ± SEM. All of the data was graphed using GraphPad Prism 6.1 (GraphPad Software; San Diego, CA). Statistical analysis was performed using One-Way ANOVA (Dunnett's multiple comparison test), and paired student t test. *P* values less than or equal to 0.05 were considered significant.

[00296] B cells were cultured using the modified *in vitro* system for differentiation of B cells into plasma cells as described above. Multicolor FITC–conjugated anti-CD20 mAb and PE–conjugated anti-CD38 mAb were used for day 4 activated B cells (CD20+CD38- cells) and day 7 plasmablasts (PBs) (CD20-CD38+). Data from 3 separate experiments representative of 3 donors are shown in Table 2. The results showed the test compound had a significant effect on B cell differentiation to the plasmablast/plasma cell lineage. It increased activated B cells and reduced plasmablasts, also reduced cell viability over time (FIGs. 12A and 12B). The activated B cells (CD20+CD38- cells) treated with the test compound (20 nM) did not change significantly between Day 4: (57.9% ± 11.5%) and Day 7 (50.5% ± 8.6%), but the test compound significantly increased activated B cells when compared with the vehicle (DMSO) control which at Day 4 (42.1 % ± 1.5%, $p < 0.05$) and at Day 7 (12.5% ± 5.7%, $p < 0.05$). Meanwhile, the test compound significantly reduced plasmablasts/plasma cells (CD20-CD38+) at Day 4 (4.8 % ± 2.3%) and at Day 7 (9.7% ± 5.4%) compared with DMSO control (Day4, 25.9 % ± 2.4% $p < 0.05$; and at Day7, 54.8% ± 5.0%, $p < 0.001$). Furthermore, the test compound dose-dependently depleted large size cell population (gate p2) in the normal B cell differentiation assay (FIG. 13). The percentage of large size cells at Day 4 of the test compound treated was 31.2%, 23.1% and 20.4% for 2 nM, 20 nM and 200 nM treatments respectively. The percentage of large size cells at Day 7 of the test compound treated was 34.9%, 19.9% and 11.94% for 2 nM, 20 nM and 200 nM treatments respectively. Comparison with DMSO control, the number was at 35.5% and 34.9% at Day 4 and Day 7 respectively.

Table 2. Test compound inhibits differentiation of plasmablasts

	Day 4		Day 7	
	DMSO	Test compound	DMSO	Test compound
CD20-CD38++ plasmablasts/plasma cells, %	25.9 ± 2.4	4.8 ± 2.3	54.8 ± 5.0	9.7 ± 5.4
CD20+CD38+ intermediated cells, %	14.7 ± 3.1	18.3 ± 5.5	22.8 ± 5.1	23 ± 7.7
CD20+CD38- activated B cells, %	42.1 ± 1.5	57.9 ± 11.5	12.5 ± 5.7	50.5 ± 8.6

[00297] The effect of the test compound on Bcell and plasma cell transcription factor (BCL-6, IRF-4, BLIMP-1, PAX5 and XBP-1) expression was evaluated by flow cytometric method. B cells were cultured as described in above and cells were harvested at day 4, day 7 for immunofluoresence staining. The cells were first stained for CD20 and CD38, and after cell permeabilization, stained for BCL-6, IRF-4, BLIMP-1, PAX5 and XBP-1, then were analyzed by gating on whole lymphocytes. Data from 3 experiments representative of 3 are shown in FIG. 14. The results indicated that the test compound (20 nM) caused a shift in transcription factor expression in plasmablasts/plasma cells. It significantly decreased IRF-4 ($p < 0.5$), BLIMP-1 ($p < 0.05$), and XBP-1 ($p < 0.05$) expression at Day 4, but significantly increased BCL-6 ($p < 0.05$) on Day 7.

[00298] Laser scanning cytometry (iCyte) was used for quantitative analysis to confirm the flow cytometry results described above. The B cells from normal donors and PBMC from SLE patients were cultured as described in above method. The cells were harvested at Day 4 and Day 7 for cytospining cells to slides, then followed double-immunofluorescence stain as described in Methods. CD38 (green) was expressed by plasmablasts/plasma cells, transcription factor (Red) BCL-6, IRF-4, BLIMP-1, PAX5, or XBP-1 was colocalized in cytoplasm or nucleus. The nucleus were counterstained with DAPI (blue). In Day 7 normal B cell samples, when compared with DMSO control, the test compound (20 nM) significantly increased BCL-6 (FIG. 15A, $p < 0.01$), decreased IRF-4 (FIG. 15B, $p < 0.001$) and BLIMP-1 (FIG. 15C, $p < 0.01$) expression in whole lymphocyte population, and significantly increased BCL-6 ($p < 0.05$), decreased IRF-4 ($p < 0.001$), BLIMP-1 ($p < 0.001$), and PAX-5 (FIG. 15D, $p < 0.05$) expression in CD38+ plasmablast/plasma cells. There was no change of XBP-1 (FIG. 15E) in both cell populations. In SLE patient PBMC, three transcription factors were tested: BCL-6, IRF-4 and BLIMP-1. The data indicated that the test compound had similar activity in these transcription factors as with healthy donor cells. The test compound dose-depend significantly increased BCL-6 expression, and inhibited IRF-4 and BLIMP-1 expression in CD38+ plasmablast/plasma cells from differentiating Day 4 and Day 7 SLE patient PBMC (FIG. 16).

[00299] Using the same B cells *in vitro* differentiation system, the activity of the test compound on CD44 and CD83 expression in B cell differentiation was further investigated. Multicolor FITC–conjugated anti-CD20 mAb, PerCP Cy5.5–conjugated anti-CD44 mAb and PE–conjugated anti-CD83 mAb are used for day 4 and day 7 cells. The effect of the test compound was evaluated from 3 separate experiments representative of 3 donors. The data indicated that the test compound had dose-dependently and significantly decreased CD44 mean fluorescence intensity (MFI) (FIG. 17, $p < 0.01$) in Day 7 B cell differentiation samples, which was due to depletion of $CD20^{high}/CD44^{high}$ cells (FIG. 18). The percentage of $CD20^{high}/CD44^{high}$ cells at Day 7 of the test compound treatment at 2 nM, 20 nM and 200 nM was 18.4%, 10.1% and 6.6% repetitively, compared with the DMSO control of 22.2%. Depletion of CD44+ cells may reduce leukocyte adhesion. The test compound also significantly increased total CD83+ cell population and enhance CD83+ expression (FIG. 19). The percentage of CD83+ cells at Day 4 of the test compound treatment of 2 nM, 20 nM and 200 nM was 24.1% ± 2.1%, 40.2% ± 3.6%, 49.5% ± 4.4% and 18.4%. The percentage of CD83+ cells at Day 7 of the test compound treatment of 2 nM, 20 nM and 200 nM was 16.3% ± 3.3%, 36.1% ± 3.4% and 51.9% ± 0.5%, compared with DMSO at 13.4% ± 2.4% and 12.9% ± 3.3 at Day 4 and Day 7 respectively.

[00300] High level IgJ chain expression in rheumatoid arthritis (RA) patients predicts lack of response to rituximab. In order to evaluate if the test compound has any activity on IgJ production, the cells were also used for intracellular staining for IgJ. The results from three donors indicated that the test compound dose-dependently and significantly reduced Ig J chain expression in Day 4 B cell differentiation cultures. It not only reduced the number of IgJ-positive cells (Day 4, 20 nM at 8.4% ± 1.5%, 200nM at 5.4% ± 1.8%; Day 7, 20 nM at 13.2% ± 2.3% and 200 nM at 7.2% ± 1.3, respectively, compared with DMSO control at 13.1% ± 1.5% and 14.4% ± 4.3 at Day 4 and Day 7 respectively), but also decreased the MFI of IgJ within the positive cells (FIG. 20). Reduced IgJ and IgG, IgM production may be a potential marker of response to the test compound in diseases like RA.

8.4 EXAMPLE 4: EFFECT OF TEST COMPOUNDS ON CYTOKINE AND CHEMOKINE PRODUCTION IN ANTI-HUMAN CD3-STIMULATED HUMAN T CELLS

[00301] This example demonstrates the effect of (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione, (*R*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione and 3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on cytokine and chemokine production in anti-human CD3-stimulated human T cells using multiplex Luminex Technology.

[00302] The following abbreviations are used:

Abbreviation	Explanation or Definition
IL	Interleukin
G-CSF	Granulocyte Colony Stimulating Factor
GM-CSF	Granulocyte Macrophage Colony Stimulating Factor
IFN-γ	Interferon Gamma
TNF-α	Tumor Necrosis Factor Alpha
RANTES	Regulated on Activation, Normal T Cell Expressed and Secreted

[00303] The following materials were used in this study:

RPMI-1640 Media supplemented with 10% FBS, 100 units/mL penicillin, 100 mg/mL streptomycin and 2 mM L-glutamine (Life Technologies)

RosetteSep® Human T- Cell Enrichment Cocktail (StemCell, Cat# 15061)

Luminex Human Cytokine/Chemokine 12-Plex Kit (Millipore, Cat# MPXHCYTO-60K-12)

Luminex IS100 instrument (Millipore)

Anti-human CD3 antibody, OKT3 clone (eBioscience, Cat# 16-0037-85)

[00304] The test compounds were prepared as stock solutions of 4 mM in DMSO. T cells were isolated from buffy coat by negative selection using the RosetteSep® T Cell Enrichment Cocktail according to manufacturer's procedures.

[00305] All 96-well plates were pre-coated with 3 μg/mL anti-human CD3 antibody in 100 μL 1X PBS for 4 hours at 37°C. The plates were washed 3 times with RPMI-1640 Complete Media prior to the T cell assay. The T cells were then plated in anti-CD3-pre-coated plates at a density of 2.5 x 10^5 cells/well in 180 μL RPMI-1640 Complete Media. The cells were treated with 20 μL 10X titrated test compounds at 10, 1, 0.1, 0.01, 0.001, 0.0001, and 0.00001 μM in duplicate. The final DMSO concentrations were 0.25%. The plates were incubated for 48 hours at 37°C, 5% CO_2. After 48 hours, the supernatants were harvested and tested by a multiplex cytometric bead array (CBA) assay for the following cytokines/chemokines: IL-2, IL-3, IL-5, IL-10, IL-13, IL-15, IL-17A, GM-CSF, G-CSF, IFN-γ, TNF-α, and RANTES. The CBA plates were analyzed on the Luminex IS100 instrument.

[00306] Data from each donor was graphed using GraphPad Prism 5.0 software and expressed as mean pg/mL ± SEM and % of DMSO control ± SEM.

[00307] The test compounds demonstrated immunomodulatory activity in anti-CD3 stimulated primary human T cells, altering the production of several cytokines and chemokines. Baseline levels of cytokines and chemokines produced by stimulated human T cells incubated with vehicle are presented in Table 3 below.

Table 3: Baseline levels of cytokines and chemokines

Cytokine/Chemokine	Baseline Amount Produced (pg/mL)
IL-2	31
IL-	3 8
IL-5	27
IL-10	449
IL-13	205
IL-17A	19
GM-CSF	132
IFN-γ	1271
TNF-α	411
RANTES	314

[00308] The test compounds enhanced IL-2, IL-3, IL-5, IL-10, IL-13, GM-CSF, IFN-γ, RANTES, and TNF-α production in stimulated human T cells. The enhancement of production by test compounds was largely concentration-dependent for most of the cytokines and chemokines, except for IL-10 and IL-5. The test compounds enhanced IL-10 production at lower concentrations but inhibited enhancement of IL-10 production at higher concentrations. The test compounds enhanced IL-5 production primarily at a single concentration within the range of concentrations that increased production of other cytokines. Relatively small amounts of IL-2, IL-3, IL-5, and IL-17A were produced in control cells in comparison with other cytokines and chemokines (Table 1). Production of IL-17A did not change much by test compounds. Measurable quantities of GCSF and IL-15 were not produced in stimulated human T cells. The effect of 3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on cytokine and chemokine production in anti-CD3-stimulated human T cells, expressed as absolute amount produced and as percentage of vehicle control cells are provided in FIGs. 21 and 22, respectively. The effect of (*R*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on cytokine and chemokine production in anti-CD3-stimulated human T cells, expressed as absolute amount produced and as percentage of vehicle control cells are provided in FIGs. 23 and 24, respectively. The effect of (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione on cytokine and chemokine production in anti-CD3-stimulated human T cells, expressed as absolute amount produced and as percentage of vehicle control cells are provided in FIGs. 25 and 26, respectively. The dashed line denotes the level equivalent to double the baseline production (EC_{200}) in FIGs. 22, 24 and 26.

8.5 EXAMPLE 5: ANTI-INFLAMMATORY ACTIVITY

[00309] Anti-inflammatory activities of 3-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-piperidine-2,6-dione, (*R*)-3-[4-(4-morpholin-4-ylmethyl-benzyloxy)-1-oxo-1,3-dihydro-isoindol-2-yl]-piperidine-2,6-dione and (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione were studied in human peripheral blood mononuclear cells (hPBMC). Luminex Technology was used to determine the inhibitory (enhancement) concentration, IC_{50} for the compounds for the simultaneous profiling of pro-inflammatory cytokines/chemokines and IL-10 (anti-inflammatory cytokine) from LPS-stimulated healthy human donor PBMCs.

[00310] 50 ml Buffy coat from healthy donors was obtained from Blood Center of New Jersey (East Orange, New Jersey). Lipopolysaccharide (strain)(Cat# L-1887) was purchased from Sigma. Milliplex kits with antibody bound beads for Luminex xMAP Technology was purchased from Millipore (Billerica, Massachusetts) and combined into multiplex format prior to assay.

7.5.1 Purification of Human Peripheral Blood Mononuclear Cells

[00311] 50 ml human buffy coat was aliquoted 25 ml each into two 50 ml conical tubes and 25 ml sterile HBSS was added to each conical tube. The tubes were gently mixed by inverting. Fifteen ml of room temperature Ficoll-Paque Plus (GE Healthcare (location); cat# 17-1440-02) was aliquoted into four 50 ml conical tubes. Then 25 ml of the Buffy coat/HBSS mixture was layered gently and slowly on top of the Ficoll. The samples were centrifuged at 450 rpm for 35 minutes. The top layered containing plasma was pipetted off and discarded. The interface containing mononuclear cells was transferred into two 50 ml conical tubes. Both conical tubes were filled to total volume of 50 ml with HBSS and centrifuged at 1200 rpm for 10 minutes. The cells were washed again in HBSS and spun at 1000 rpm for 10 minutes. Cell pellet was resuspended with 20 ml RPMI complete medium (RPMI/5% human sera/1x pen/strep/glut) and counted.

7.5.2 Treatment of Human Peripheral Blood Mononuclear Cells

[00312] One hundred μl (2x106/ml) of hPBMCs were added to each well of a 96 well flat-bottom plate (final cell count = 2x105/well) and incubated at 37 °C for 1 hour. Twenty μl (10x) compound was added to each test well and twenty μl medium containing 2.5% DMSO was added to each control well ([DMSO]final=0.25%) and plate was incubated for 1 hour at 37 °C. Cells were then stimulated with 80 μl of 2.5 ng/ml LPS ([LPS]final=1 ng/ml) and incubated for 18 hours at 37 °C.

[00313] 50 μl supernatant from each well was transferred into 3 new round-bottomed 96 well plates and stored at -20 °C for Luminex analysis. Duplicate wells were performed for each sample.

7.5.3 Luminex Analysis

[00314] Supernatant samples were analyzed for cytokines in multiplex format according to the manufacturer's instructions (Millipore, Billerica, Ma 01821) using a

Luminex IS100 instrument. IL-12 and GM-CSF analyses were done in a two-plex format using neat supernatants while all other cytokines were done in a multiplex format using supernatants diluted 1:20. Data analysis was performed using Upstate Beadview software. IC_{50}s were calculated using non-linear regression, sigmoidal dose-response, constraining the top to 100% and bottom to 0%, allowing variable slope. The EC_{50}s were based on the upper constraint of the sigmoidal curves equaling 246.9%, representing the average IL-10 enhancement produced by pomalidomide (control) at 10 μM and the lower constraint to 100%. The IC_{50} were performed using GraphPad Prism v5.00. The data values represent the mean + SEM (standard error of the mean) of n (number of experiments in duplicate).

[00315] As demonstrated by data in Table 4 below and FIGs. 27, 29 and 31, test compounds have varied potencies for the inhibitions of the multiple cytokines examined, e.g., Il-6, IL-8, IL-1β, GM-CSF, MDC, MIP-1α, MIP-1β, and TNF-α, in general. Also, these compounds enhanced production of IL-10, MCP-1, and RANTES with various potencies as provided in Table 5 and FIGs 28, 30 and 32.

Table 4: Summary of Cytokine Inhibitory Profile of Test Compounds

Cytokine	Racemate IC_{50} (μM)	*R*-enantiomer IC_{50} (μM)	*S*-enantiomer IC_{50} (μM)
IL-6	0.01	0.083	0.0038
IL-8	>10	>10	>10
IL-1β	0.00085	0.0062	0.00046
GM-CSF	0.0092	0.039	0.0022
MDC	0.0026	0.012	0.0021
MIP-1α	0.19	0.45	0.028
MIP-1β	>10	>10	>10
TNF-α	0.0018	0.0095	0.00059

Table 5: Cytokine Profile Summary of - Mean % of Control at 0.1 μM

Cytokine	Racemate (% of control)	*R*-enantiomer (% of control)	*S*-enantiomer (% of control)
IL-10	371	442	379
MCP-1	208	223	233
RANTES	153	151	153

8.6 EXAMPLE 6: EFFECT ON HUMAN NATURAL KILLER (NK) CELL FUNCTION IN RESPONSE TO IGG/RITUXIMAB

[00316] In this example, the capacity of test compounds to enhance human NK cell function in response to IgG/Rituximab was studied. The immunomodulatory activity of the test compounds was compared in two assays of natural killer (NK) cell functions (1) IgG- and IL-2-induced interferon-gamma (IFN-γ) production.

[00317] The materials used in the study and their sources are provided below:

Buffy Coat from healthy volunteers (Blood Center of New Jersey)

Ficoll-Hypaque Plus (Fisher Scientific Co LLC, PA, Cat # 17144002)

RPMI-1640 Medium supplemented with 10% FBS (fetal bovine serum), 100 units/mL penicillin,

100 mg/mL streptomycin, and 2 mM L-glutamine (Invitrogen, Cat # 21870-076)

RPMI-1640 Medium (without phenol red) supplemented with 10% FBS, 100 units/mL penicillin,

100 mg/mL streptomycin, and 2 mM L-glutamine (Invitrogen, Cat # 11835-030)

Rituximab (Rituxan, Roche, Inc.) (Cat No. DIN 02241927, Lot No. B50177)

Human AB+ serum (Gemini Bio Products, CA, Cat # 100-512)

CytoTox 96 Non-Radioactive Cytotoxicity Assay Kit (Promega, WI, Cat # G1780)

RosetteSep Human NK Cell Enrichment Cocktail (Stem Cell Technologies, Vancouver, BC, Cat# 15065)

Mouse anti-human CD56+ conjugated APC (BD Biosciences, CA, Cat # 555518)

Human Immunoglobulin G from Serum (IgG) (Sigma, St. Louis, MO; Cat # I2511-10MG)

Human Recombinant IL-2 (R&D Systems, MN, Cat # 202-IL-050/CF)

Human IFN-gamma ELISA Kit (ThermoFisher, Cat # PIEHIFNG5)

[00318] The following cell lines were used:

Activated B cell-like - diffuse large B cell lymphoma (ABC-DLBCL): Riva cells (NCI, MD)

Germinal center B-cell-like - diffuse large B cell lymphoma (GCB-DLBCL):

WSU-DLCL2 (Celgene Signal, CA)

Farage (ATCC, VA)

Follicular lymphoma: DoHH2 (DSMZ, Germany)

Burkitt's lymphoma (BL): Raji (ATCC, VA).

[00319] NK cells from healthy donors were isolated from buffy coat blood by negative selection using the RosetteSep NK cell enrichment cocktail (Stem Cell Technologies, Vancouver, BC) prior to Ficoll-Hypaque (Fisher Scientific Co LLC, PA) density gradient centrifugation following the manufacturers' instructions. CD56+ NK cells were isolated to ~85% purity, as determined by flow cytometry (BD Biosciences, CA).

7.6.1 NK IgG-induced Interferon–Gamma (IFN-Gamma) Assay

[00320] Ninety-six-well flat-bottom plates were coated with 100 μg/mL of human IgG (Sigma) overnight at 4°C. The next day, unbound IgG was washed away with cold 1X PBS. NK cells were then plated in the IgG-coated 96-well plates at 2 x 105 cells per well in 180 μL RPMI-1640 Media and 10 ng/mL of rhIL-2 (R & D Systems, MN) was added. Test compounds were added in a volume of 20 μL DMSO. Final concentrations of test compounds were 0.0001, 0.001, 0.01, 0.1, 1, or 10 μM. Final DMSO concentrations were 0.25%. After 48 hours, the supernatants were harvested and analyzed by ELISA for IFN-γ production.

[00321] Data used to determine the ability of test compounds to enhance NK cell IFN-γ production in response to immobilized IgG and rhIL-2 stimulation was analyzed for each donor using GraphPad Prism v5.0 software. The data are presented in two ways, (1) as the absolute amount if IFN-γ produced (pg/mL ± SEM) and (2) as the percentage of the amount of IFN-γ produced in the presence of 1 μM pomalidomide. The EC_{50} is the concentration of test compound providing half-maximal IFN-γ production, with maximal production defined as the amount of IFN-γ produced in the presence of 1 μM pomalidomide. EC_{50} values were calculated using non-linear regression, sigmoidaldose-response constraining the top to 100% and bottom to 0% allowing for a variable slope.

Table 6

Compound	EC_{50}

Racemate	0.037 μM
R-enantiomer	0.016 μM
S-enantiomer	0.012 μM

[00322] The test compounds enhanced NK cell IFN-γ production in a dose dependent manner in response to immobilized IgG and IL-2 stimulation. Results for the racemate, *R*-enantiomer and *S*-enantiomer are provided in FIGs. 33-35 (expressed as pg/mL of IFN-γ produced), respectively. FIGs. 36-38 provide results expressed as a percentage of increased IFN-γ produced relative to the IFN-γ produced in the presence of pomalidomide at 1 μM for the racemate, *R*-enantiomer and *S*-enantiomer, respectively. Each value plotted in FIGs. 33-38 represents the mean of 12-14 determinations ± SEM.

8.7 EXAMPLE 7: HUMAN VASCULAR ENDOTHELIAL CELL PROLIFERATION, TUBE FORMATION, MIGRATION, AND INVASION ASSAYS

[00323] In this example, racemate refers to 3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione, *R*-enantiomer refers to (*R*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione and *S*-enantiomer refers to (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

[00324] Human Umbilical Vascular Endothelial Cells Proliferation Assay: Human umbilical vascular endothelial cells were thawed and grown in EGM2 medium until passage 3 to 6 for all proliferation assays. Human umbilical vascular endothelial cells were trypsinized, washed with 20% FBS/M199 medium and plated with the same medium at 104 cells/100 μL per well to 96-well cell culture plates. The plates were incubated overnight at 37 °C to allow cells to adhere. The cells were then starved in 1% FBS/M199 medium for 18 hours after washing with the same medium 3 times. For optimization of the concentration of the growth factors in the HUVEC proliferation assay, 100 μL/well of the 2X serial diluted growth factors, starting at 100 ng/mL, were added to HUVECs in duplicate for 72 hours at 37 °C in a humidified cell culture incubator with 5% CO_2. For analysis of test compounds, a serial dilution of the test compounds in 0.4% DMSO/1% FBS/M199 medium in duplicate was made from the 10 mM stock. Fifty microliters per well of the serially diluted test compounds (10, 1.0, 0.1, 0.01, 0.001, 0.0001, 0.00001 μM) were added to the cells for 1 to 2 hours at 37 °C. The final DMSO concentration in the cells is 0.1%. Then 50 μL of 4X final concentration of relative growth factors was added to each well in duplicate for 72 hours at 37 °C in a humidified cell culture incubator with 5% CO_2. Thymidine incorporation was measured by adding one microcurie of 3H-thymidine (Amersham) in 20 μL medium to each well and incubated at 37 °C in a humidified cell culture incubator with 5% CO_2 for 5 to 6 hours. The cells were then trypsinized and harvested onto UniFilter GF/C filter plates (Perkin Elmer) by using the cell harvester (Tomtec). After the plates were air dried, 20 μL/well of Microscint 20 (Packard) was added then the plates were analyzed in TopCount NXT (Packard). Each well was counted for one minute. The experiments were performed in duplicate in each of 3 donors.

[00325] Human Umbilical Vascular Endothelial Cell Tube Formation Assay: Compounds were tested in the growth factor-induced HUVEC tube formation assay. The tube formation plates were incubated at 37 °C for 30 minutes for matrigel to polymerize. The HUVECs were starved in 0.1% BSA basal EBM2 medium for 5 hours after washing with the same medium 3 times. The cells were trypsinized and centrifuged. Then 25 μL of 4X serially diluted compounds (10, 1, 0.1, 0.01, 0.001, 0.0001, 0.00001 μM) were added in duplicate with 50 μL of 2 x 104 cells/well to tube formation plates coated with matrigel. Fifty μL of 4X VEGF (final concentration = 25 ng/mL) or bFGF (final concentration = 10 ng/mL) were added to the plates. The cells were then incubated overnight (~18 hours) at 37 °C in a humidified incubator. The tubule webs were stained with calcein AM at 4 μg/μL in 2% FBS/HBSS for 30 minutes and images taken by fluorescence microscopy. The tubules were quantified by the MetaMorph tube formation software program for tube area and tube length.

[00326] Human Umbilical Vascular Endothelial Cell Invasion Assay: In the HUVEC invasion assay, the concentration of human fibronectin is optimized to provide a suitable protein structure for adherent cells to attach to the membrane and allow free migration in response to an angiogenic stimulus (*e.g.* VEGF, bFGF, or HGF) in the lower chamber of the insert plate. HUVECs were starved in 0.1% BSA EBM2 medium for 6 hours after washing with the same medium 3 times. The cells were then trypsinized and centrifuged to remove the remaining trypsin. Then ~0.5 to 1 x 106 cells in 125 μL/well and 125 μL of 8X serially diluted compounds (10, 1, 0.1, 0.01, 0.001 μM) were added to the upper chamber of the BD Falcon 24-well and 96-well insert plates in duplicate and incubated for ~1 to 2 hours. (The plates contain a fluorescence blocking, microporous [3.0 μm pore size] PET membrane that has been evenly coated with human fibronectin.) Seven hundred fifty microliters of a 1.33 X stock solution of

VEGF (final concentration of 25 ng/mL), bFGF (final concentration of 10 ng/mL), or HGF (final concentration of 25 ng/mL) were then added to the lower chamber. The cells were incubated for 22 ± 1 hours at 37 °C. The migrated cells were stained with calcein AM at 4 μg/mL in HBSS containing 2% FBS, using 500 μL/well in 24-well plates and 200 μL/well in 96-well plates. The plates were incubated at 37 °C for 90 minutes and read in a fluorescence plate reader.

[00327] The percentage inhibition of cell proliferation, tube formation, migration, and invasion was calculated by subtracting the result for unstimulated DMSO control from test sample results, averaging all replicates, and normalizing to the growth factor-stimulated DMSO control (0% inhibition). The IC_{50} values were calculated by using GraphPad Prism 5.0.

[00328] Human Umbilical Vascular Endothelial Cells Proliferation Assay Results: Results from the growth factor optimization study indicated that the optimal concentrations of VEGF, bFGF, and HGF for induction of proliferation were 25, 10, and 25 ng/mL respectively. The test compounds were examined with optimized growth factor concentrations and results indicated that the racemeate, *S*-enantiomer, and *R*-enantiomer did not inhibit VEGF-, bFGF-, or HGF-induced HUVEC proliferation (FIG. 39). However, there was a significant enhancement of proliferation observed in the VEGF- and HGF-treated HUVECs by *S*-enantiomer (VEGF-treated: 1 – 10 μM; HGF-treated: 0.1 – 1 μM). Also there was a significant enhancement observed in the bFGF-treated HUVECs by racemate (0.01 – 1 μM), and *R*-enantiomer (0.1 – 1 μM). IC_{50} values are summarized in the Table 7.

Table 7. Summary of IC_{50} Values from Growth Factor-induced Human Umbilical Vascular Endothelial Cell Proliferation Studies

Test Compounds	VEGF (25 ng/mL) IC_{50} Values (μM)	bFGF (10 ng/mL) IC_{50} Values (μM)	HGF (25 ng/mL) IC_{50} Values (μM)
Racemate	>100	99	24
R-enantiomer	>100	76	38
S-enantiomer	>100	52	51

[00329] Human Umbilical Vascular Endothelial Cell Tube Formation Assay Results: The test compounds displayed a trend toward inhibiting VEGF-induced HUVEC tube formation in terms of both tube length and tube area (FIG. 40). All compounds demonstrated a dose-dependent effect on VEGF-induced HUVEC tube formation. *R*-enantiomer showed significant inhibition ($p < 0.05$ vs stimulated DMSO control) of tube area and length at 10 μM. There was also a trend for the compounds to inhibit bFGF-induced HUVEC tube formation in terms of both tube length and tube area (FIG. 40), although the effect was less pronounced than the effects on VEGF-induced HUVEC tube formation.

[00330] Human Umbilical Vascular Endothelial Cell Invasion Assay Results: 3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione, (*R*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione and (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione significantly inhibited VEGF-, bFGF-, and HGF-induced HUVEC invasion in a dose-dependent manner (FIG. 41). The compounds were more potent against VEGF- and bFGF-induced HUVEC invasion than against HGFinduced HUVEC invasion (Table 8). The IC_{50} value was < 0.3 nM for inhibition of VEGFinduced HUVEC invasion by the test compounds. The IC_{50} of racemate (0.4 nM) and *S*-enantiomer (< 0.1 nM) were more than ten times as potent as the *R*-enantiomer (13 nM) (Table 8).

Table 8. Summary of the Effect of Test Compounds on Growth Factor-induced Human Umbilical Vascular Endothelial Cell Invasion

Test Compounds	VEGF-induced invasion IC_{50} Values (μM)	bFGF-induced invasion IC_{50} Values (μM)	HGF-induced invasion IC_{50} Values (μM)
Racemate	0.00014	0.00042	0.59
R-enatiomer	< 0.0001	0.013	0.45
S-enantiomer	< 0.0001	< 0.0001	0.019

8.8 EXAMPLE 8: LUPUS/FIBROSIS MOUSE MODEL STUDY

[00331] In this example, sensitivity (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione was tested in two lupus-prone mouse

strains: MRL/MpJ-Faslpr/J mouse model of systemic lupus erythematosus and NZBWF1/J mouse model of systemic lupus erythematosus. The test compound was administered in both models at 30 mg/kg.

[00332] In MRL/MpJ-Faslpr/J mouse model of systemic lupus erythematosus, peripheral blood B cells showed no change at week 4. Splenic B cells showed 37% increase and anti-double stranded DNA autoantibody level showed 25% decrease at week 4.

[00333] In NZBWF1/J mouse model of systemic lupus erythematosus, peripheral blood B cells showed 25% decrease at week 4, splenic B cells showed no change, and anti-double stranded DNA autoantibody level showed 86% increase at week 4.

8.9 EXAMPLE 9: DERMAL FIBROSIS MOUSE MODEL STUDY

[00334] In this example, (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione was tested in the bleomycin-induced skin fibrosis model using both prophylactic and therapeutic dosing regimens. Bleomycin is an outmoded anticancer therapeutic that has been demonstrated to cause fibrosis in the lung. In animal models it will similarly induce injury and fibrosis at the site of delivery.

[00335] The following abbreviations are used in this example:

Abbreviation or Specialist Term	Explanation or Definition
ANOVA	Analysis of Variance
α-SMA	Alpha Smooth Muscle Actin
CMC	Carboxymethyl Cellulose
ECM	Extracellular Matrix
NaCl	Sodium Chloride
PO	orally
QD	Once daily dosing
SSc	Systemic Sclerosis

[00336] DBA/2 mice were used in this study. Eight animals were used per treatment group in the study. Mice were kept in the animal house under standard conditions with food and water ad libidum.

[00337] The vehicle, 0.5% carboxymethyl cellulose (CMC)/0.25% Tween 80, was prepared in distilled H_2O and dissolved overnight on a magnetic stirrer (add 0.5g CMC;

Sigma #C9481) and 0.25ml Tween 80 (Sigma #P8074) to 99.75 ml to make a total of 100 ml 0.5% CMC/0.25% Tween 80).

[00338] The test compound powder was weighed out and suspended fresh daily in the vehicle 0.5% CMC/0.25% Tween 80, to avoid drug hydrolysis in the aqueous medium. The compound was suspended, not dissolved, in this vehicle. The formulation was homogenized with a Teflon pestle and mortar (Potter-Elvehjem tissue grinder) using a motorized Eberbach tissue homogenizer. The daily drug stock concentration used in these studies was 3 mg/ml.

[00339] Bleomycin was obtained from the pharmacy of the University of Erlangen-Nuremberg and freshly prepared once a week. Skin fibrosis was induced in 6-week-old DBA mice by local intracutaneous injections of 100 μl of bleomycin dissolved in 0.9% NaCl, at a concentration of 0.5 mg/ml, every other day in defined areas of 1.5 cm^2 on the upper back.

7.9.1 Study Design

[00340] The mouse model of bleomycin induced dermal fibrosis is widely used to evaluate anti-fibrotic therapeutics. In this model, a localized dermal fibrosis is induced by intradermal injections with bleomycin every other day for 3 weeks. This model resembles early, inflammatory stages of SSc. To evaluate potential effects on prevention of fibrosis, treatment was initiated simultaneously with the first bleomycin injection. To study the effect of test compound on prevention of bleomycin-induced dermal fibrosis *in vivo*, the treatments were divided into following groups:

- Control group: Intradermal injection of NaCl for 3 weeks. Treatment consisted of administration of the vehicle (0.5% CMC/0.25% Tween 80).
- Untreated bleomycin group: Intradermal injection of bleomycin for three weeks. Administration of the vehicle (0.5% CMC/0.25% Tween 80).
- Test compound group: Intradermal injection of bleomycin for three weeks. The test compound was administered at 30 mg/kg; PO, QD.
- Positive control group: Intradermal injection of bleomycin for three weeks. Injection of Imatinib (50 mg/kg; IP, QD). Imatinib mesylate has previously been shown to exert potent anti-fibrotic effects in bleomycin induced dermal fibrosis. *See* Akhmetshina A. *et al., Arthritis Rheum* 2009; 60(1):219-224.

[00341] To evaluate regression of fibrosis, a modified model of bleomycin induced dermal fibrosis was used. Mice were pre-challenged with bleomycin to induce a robust skin fibrosis. One group received treatment with the test compound, while challenge with bleomycin was ongoing for additional three weeks. The outcome of this group was compared to mice challenged with bleomycin for six weeks (prevention of further progression) and to mice challenged with bleomycin for three weeks followed by NaCl for additional three weeks (induction of regression). The following groups were used in the regression study:

- Control group: Intradermal injection of NaCl for six weeks. Control treatment consisted of administration of the vehicle.
- Untreated bleomycin group 1 (regression): Intradermal injection of bleomycin for three weeks followed by intradermal injections of NaCl for another three weeks. Treatment consisted of administration of the vehicle. Untreated bleomycin group 2 (prevention of progression): Intradermal injection of bleomycin for six weeks. Treatment consisted of administration of the vehicle.
- Test compound group: Intradermal injection of bleomycin for six weeks. The test compound was administered at 30 mg/kg; PO, QD.
- Positive control group: Intradermal injection of bleomycin for six weeks. Injection of Imatinib (50 mg/kg; IP, QD)

7.9.2 Experimental Procedure

[00342] Dermal thickness was determined by staining with hematoxylin and eosin and activated fibroblasts by using immunohistochemistry for alpha smooth mucle actin (α-SMA). The dermal thickness, as determined by the modified Rodnan Skin Score, is currently the most common primary outcome in human clinical trials for anti-fibrotic agents in SSc. Skin sections were stained with hematoxylin/eosin for better visualization of the tissue structure. Dermal thickness was analyzed with a Nikon Eclipse 80i microscope (Nikon, Badhoevedorp, The Netherlands) by measuring the maximal distance between the epidermal–dermal junction and the dermal–subcutaneous fat junction at 4 different skin sections in each mouse. The evaluation was performed by 2 independent examiners.

[00343] For quantification of myofibroblasts, skin sections were deparaffinized and incubated with 5% bovine serum albumin for 60 minutes. Cells positive for α-SMA were detected by incubation with monoclonal anti–α-SMA antibodies (clone 1A4; Sigma-Aldrich, Steinheim, Germany) for 2 hours at room temperature followed by incubation with 3% hydrogen peroxide for 10 minutes. Goat anti-rabbit antibodies labeled with horseradish peroxidase (Dako, Hamburg, Germany) were used as secondary antibodies. The expression of α-SMA was visualized with 3,3-diaminobenzidine tetrahydrochloride (Sigma-Aldrich). Monoclonal mouse IgG antibodies (Calbiochem, San Diego, CA) were used as controls.

[00344] In addition, the amount of collagen in lesional skin will be measured with the SirCol collagen assay; RNA and plasma of all mice were saved for further analyses.

[00345] The test compound significantly decreases dermal thickness of lesional skin in the bleomycin dermal fibrosis mouse model. The test compound at 30 mg/kg; PO, QD significantly prevented dermal thickening by approximately 25 ± 0.49 % ($p < 0.001$, FIG. 42).

[00346] Representative photomicrographs of hematoxylin and eosin stained skin sections are shown in FIG. 43. Dermal thickness was assessed by measuring the maximal distance between the epidermal–dermal junction and the dermal–subcutaneous fat junction. The line drawn between the junction points shows the relative thickness in the treatment groups.

[00347] To determine the effect of the treatments on fibroblast activation, α-SMA + myofibroblasts were counted in lesional skin sections. As shown in FIG. 44, the test compound at 30 mg/kg; PO, QD reduced the number of myofibroblasts by 24 ± 0.09 % ($p < 0.05$). Imatinib at 50 mg/kg reduced dermal thickening by 60 ± 0.34 % ($p < 0.0001$) and myofibroblast numbers by 81 ± 0.11% ($p < 0.0001$).

7.9.3 Effect on the regression of bleomycin induced dermal fibrosis

[00348] The inhibitory effects of the test compound on progression of fibrosis were also confirmed in the modified bleomycin model designed to investigate potential regression of fibrosis. As shown in FIG. 45, the test compound at 30 mg/kg; PO, QD had no effect on dermal thickening in the regression model. FIG. 46 shows photomicrographs of representative hematoxylin and eosin stained skin sections. Dermal thickness was assessed by measuring the maximal distance between the epidermal–dermal junction and the dermal–subcutaneous fat junction. The line drawn between the junction points shows relative thickness in the treatment groups. FIG. 47 shows that the test compound did not have an effect on the numbers of myofibroblasts. Imatinib at 50 mg/kg reduced bleomycin induced dermal thickness by 50 ± 0.3 % ($p < 0.0001$) and myofibroblast numbers by 78 ± 0.15 % ($p < 0.0001$).

8.10 EXAMPLE 10: EFFECT IN TSK-1 MOUSE MODEL

[00349] The antifibrotic effects of (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione were tested in the murine tight skin-1 (Tsk-1) mouse model.

[00350] First, the inhibitory effects of the compound on fibrosis in the Tsk-1 tight skin mouse model were also investigated. As shown in Figure 48, the compound at 30 mg/kg reduced the hypodermal thickening by 45% ($p \leq 0.001$), compared to 58% reduction by imatinib at 50 mg/kg ($p \leq 0.001$). The elevated collagen content of the skin, as measured by hydroxyproline levels, was reduced 38% by the compound, and 67% by imatinib ($p \leq 0.001$).

[00351] Next, to examine the effect of the compound on the overexpression of TGF-β pathway genes in Tsk-1 mouse skin, qRT-PCR was used to measure mRNA levels for six genes: CTGF, PAI-1, COL1A1, α-smooth muscle actin (ALPHA SMA), cartilage oligomeric protein 1 (COMP), and TGFB1. Overexpression was defined as the excess mRNA levels observed in Tsk-1 mouse skin compared to normal pa/pa mouse skin. Among these six genes, only four (CTGF, PAI-1, COL1A1, and TGFB1) were expressed to a significantly higher level in Tsk-1 compared to normal pa/pa mice. The compound (30 mg/kg) significantly reduced the overexpression of CTGF and COL1A1 by 79% ($p \leq 0.001$) and 129% ($p \leq 0.001$), respectively (Figure 49). PAI-1 and TGFB1 gene overexpression was not inhibited by the compound. These results indicate that the compound may reduce skin fibrosis by blocking the overexpression of some profibrotic genes within the TGF-β pathway.

[00352] To further examine the effect of the compound on the expression of fibrotic genes of normal (NL) and systemic sclerosis (SSc) cells, the following procedures were followed:

Cell cultures: Human normal and scleroderma skin fibroblasts were cultured in DMEM containing 10% fetal bovine serum (FBS). The cells were maintained in a humidified 5% CO_2, 95% air incubator at 37 °C. After confluence was reached, the cells were harvested with 0.05% trypsin and subcultured. Cells were used in the 3rd-5th passage.

Experimental design: Cells were grown to 70-80% confluence and placed into quiescent state by a reduction in serum concentration to 0.4% for overnight. The effects of the compound on TGFβ fibrotic effects and on NL and SSc fibrotic gene expression were tested.

Effects on TGFβ induction of fibrotic gene expression: NL fibroblasts were pretreated with the compound for 30 minutes followed by the addition of TGF-β1 to observe the effects of the compound on TGFβ induced fibrosis gene expression.

Effects of the compound on SSc-FB: SSc fibrobasts were treated with the compound at different concentration and gene expression levels of Collagen 1A1 (COL1), α-smooth muscle actin (α-SMA), fibronectin (FN), matrix metallopeptidase 1 (MMP1), plasminogen activator inhibitor (PAI), and DNA (cytosine-5-)-methyltransferase 1(Dnmt1) were determined 24 hours later by real time PCR.

Quantitative Real-Time PCR: Total RNA was extracted from cells using RNeasy kit. RNA concentration was measured and 1ug of RNA was reverse transcribed to cDNA using RT-First strand kit. The cDNA was then amplified using respective primers and Power SYBR Green PCR Master Mix. The amplicon (150-200bp) was detected by ABI 7500 Real Time PCR System. All the target genes were normalized to GAPDH and relative fold changes were calculated. Each sample was assessed in triplicate.

[00353] As shown in Figure 50, the compound dose dependently reduced the expression of COL1, aSMA and FN mRNAs in SSc fibroblasts. Similarly, the expression of PAI (Figure 51) and Dnmt1 (Figure 52) was also dose dependently reduced by the compound in SSc fibroblasts. As also shown in Figure 51, the expression of MMP-1 was dose dependently increased by the compound in SSc fibroblasts. The results demonstrate that the compound potently regulates key fibrotic factors, indicating the efficacy of the compound in the treatment of SSc.

[00354] In addition, the levels of cereblon in normal and SSc fibroblasts and skin tissues were examined. As shown in Figures 53 and 54, higher levels of cereblon were observed in both SSc fibroblasts and skin tissues as compared to the normal tissues. This indicates that an elevated level of cereblon is involved in SSc.

8.11 EXAMPLE 11: TARGETING CEREBLON FOR B CELL DYSCRASIAS

[00355] The effect of (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione ("Compound IA") on CRBN binding, ubiquitination, and cell proliferation was profiled. CRBN is a component of the E3 ubiquitin ligase complex including CUL4A, DDB1, and ROC-1 and was found to be the molecular binding target of thalidomide, lenalidomide, and pomalidomide.

[00356] Binding studies to CRBN were conducted using thalidomide analog-conjugated beads in a competitive assay. Endogenous CRBN from human U266 multiple myeloma ("MM") cells was measured by incubating cell extracts with varying concentrations of either Compound IA or pomalidomide as a positive control. Affinity beads coupled to a thalidomide acid analog were incubated with the U266 extracts and, after extensive washing of the beads, the bound proteins were eluted. CRBN binding to the thalidomide-coupled affinity beads was determined by quantitative CRBN immunoblot determination.

[00357] CRBN ubiquitination was measured in HEK293T cells, which were transfected with an amino-terminal His-biotin-tagged CRBN construct, then preincubated with compounds for one hour followed by treatment with the MG132 proteasome inhibitor (to arrest degradation of ubiquitinated proteins). Cells were lysed and processed to measure CRBN ubiquitination by SDS-PAGE and immunoblot analysis using an anti-ubiquitin antibody. Cell proliferation studies were conducted in lenalidomide-sensitive and refractory multiple myeloma cells. Lenalidomide-resistant or sensitive H929 MM cell lines were treated with Compound IA for 5 days, and then cell proliferation and viability were assessed by 7-aminoactinomycin D ("7-ADD") staining. T-cell costimulation was measured in purified primary human T cells stimulated using immobilized anti-CD3 antibody in cell culture for 2 days, and cytokine secretion was measured by ELISA.

[00358] Immunoglobulin M and G ("IgG and IgM") production was measured from normal donor peripheral blood mononuclear cells by culturing in the presence of the B cell differentiation factors recombinant human IL-2 (20U/mL), IL-10 (50ng/mL), IL-15 (10ng/mL), His-tagged CD40 Ligand (50ng/mL), polyHistidine mouse IgG1 antibody (5μg/mL), and ODN 2006-Human TLR9 ligand (10μg/mL) for 4 days, followed by IL-2, IL-10, IL-15, and IL-6 (50ng/mL) for an additional 3 days. IgM and IgG were measured by ELISA.

[00359] In the competitive CRBN binding studies, preincubation with pomalidomide at concentration of 3uM resulted in approximately 50% less CRBN bound to the affinity beads, while Compound IA at a concentration of 0.1μM resulted in similar CRBN binding. CRBN ubiquitination studies in the transfected HEK293T cells resulted in the following potencies: Compound IA IC_{50}= 0.19μM; lenalidomide IC_{50}= 12.9μM; and pomalidomide IC_{50}= 21.6μM. The IC_{50} values for inhibition of proliferation by

Compound IA shifted from 0.01μM in the parental H929 cell line and 0.04μM in the DMSO-treated subclone to 0.51-1.58μM in the lenalidomide resistant subclones.

[00360] A 50% decrease in cell cycle (S-phase) was evident after 24 hours of treatment of H929 cells with Compound IA. At 48 hours, Compound IA decreased expression of survivin and retinoblastoma protein ("pRB") and increased expression of the cyclin-dependent kinase inhibitor p27. Compound IA co-stimulated IL-2 production by T cells with an EC_{50} of approximately 0.29nM, compared with 10nM for pomalidomide. Compound IA inhibited IgM and IgG production with an IC_{50} of 0.35 and 2.1nM, respectively, compared to 17nM and 63nM for pomalidomide.

[00361] The results indicate that Compound IA binds to CRBN with approximately 30-fold higher affinity than pomalidomide, and inhibits CRBN ubiquitination with approximately 110-fold greater potency than pomalidomide in this system. Compound IA is approximately 34-fold more potent than pomalidomide for co-stimulating IL-2 production by T cells, and is 30 to 48-fold more potent than pomalidomide for inhibiting immunoglobulin production.

8.12 EXAMPLE 12: INHIBITION OF B CELL DIFFERENTIATION TO THE PLASMABLAST AND PLASMA CELL LINEAGE

[00362] The effects of cereblon ("CRBN") targeting on the differentiation of B cells to the plasmablast and plasma cell lineages, an in vitro model of primary human B cell differentiation was developed.

[00363] CD19+ peripheral blood human B cells from normal donors, or total peripheral blood mononuclear cell PBMC for patients with systemic lupus erythematosus ("SLE"), were cultured in the presence of interleukin ("IL")-2, IL-10, IL15, TLR9 agonist, and CD40L for 4 days, followed by IL-2, IL-6, IL-10 and IL-15 for another 3 days. Cells were counted, viability assessed, and expression of CD20, CD38, CD44, and CD83 were measured by flow cytometry. Plasmablast lineage factors IRF-4, BLIMP-1, XBP-1, and IgJ, and germinal center markers PAX-5 and BCL-6 were measured by qRT-PCR. Interacellular protein expression was measured by laser scanning cytometry. Secreted immunoglobulins IgG and IgM were measured by ELISA.

[00364] In normal B cell cultures, (S)-3-(4-((4-morphlinomethyl)benzyl)oxy)-1-oxoisoindolin-2-yl)piperidine-2,6-dione ("Compound I-S") reduced the percentage of total viable cells in these cultures after 4 days to 69.6% ($P \leq 0.05$) or 35.8% of control ($P \leq 0.001$) at 20nM or 200nM Compound I-S, respectively. Compound I-S decreased the percentage of viable CD20-CD38+ plasmablasts on day 7 from 30.4% in control cultures in a dose-dependent manner to 27.3%, 2.1%, and 0.4% at 2nM, 20nM, and 200nM, respectively. On day 7, qRT-PCR analysis showed that Compound I-S (20nM) reduced expression of the plasmablast lineage factors IRF-4, BLIMP-1, XBP-1, and IgJ gene expression to 20.5%, 14.3%, 15.1%, and 31.5% of control, respectively ($P \leq 0.001$).

[00365] By intracellular flow cytometry, Compound I-S (20nM) significantly decreased IRF-4 ($P<0.5$), BLIMP-1 ($P<0.05$), and XBP-1 ($P<0.05$) protein expression at day 4, but significantly increased BCL-6 ($P<0.05$) protein expression on day 7. By laser scanning cytometry on day 7, Compound I-S (20nM) reduced CD38+ cell intracellular protein expression of IRF-4 ($P \leq 0.001$), and BLIMP-1 ($P \leq 0.001$), and increased BCL-6 expression ($P \leq 0.05$) (n=3). Compound I-S inhibited secreted IgG production with an IC50= 1.8nM (n=3).

[00366] In PBMC from SLE patients, Compound I-S (20nM) had similar effects as in normal B cells, reducing BLIMP-1, XBP-1, and IgJ gene expression to 52.8%, 49.2%, and 13.6% of control, respectively ($P \leq 0.001$) (n=3). Compound I-S (20nM) significantly reduced CD38+ plasmablast intracellular protein expression of BLIMP-1 ($P \leq 0.01$) and IRF-4 ($P \leq 0.001$), and increased BCL-6 ($P \leq 0.05$) (n=3). Compound I-S inhibited secreted IgM and IgG production by SLE patient PBMC with IC50s of 0.9nM and 3.2nM, respectively (n=3).

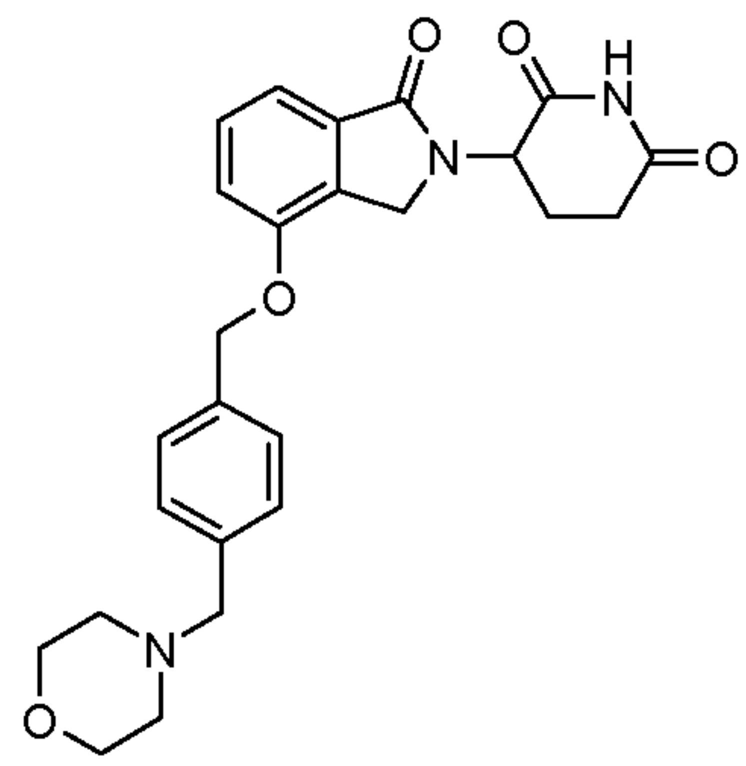
[00367] These results demonstrate that targeting of the E3 ubiquitin ligase complex substrate co-receptor CRBN with the small molecule immunomodulatory compound Compound I-S results in potent inhibition of B cell differentiation to the plasmablast lineage, as shown by a reduction in the percentage of viable CD38+ cells, a decrease in BLIMP-1, XBP-1, IRF-4, and IgJ gene and protein expression, and inhibition of secreted immunoglobulin production. These data implicate the CUL4-CRBN complex in the differentiation of B cells to the plasma cell lineage.

[00368] The present invention is not to be limited in scope by the specific embodiments described herein. Indeed, various modifications of the invention in addition to those described will become apparent to those skilled in the art from the foregoing description and accompanying figures. Such modifications are intended to fall within the scope of the appended claims.

[00369] Various publications, patents and patent applications are cited herein, the disclosures of which are incorporated by reference in their entireties.

What is claimed is:

1. A method for treating, preventing or managing an immune-related disease or an inflammatory disease comprising administering to a patient in need thereof an effective amount of a compound of formula I



I,

or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixture thereof.

2. The method of claim 1, wherein the compound is (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione or a pharmaceutically acceptable salt, solid form, solvate, hydrate, tautomer, stereoisomer or racemate thereof.

3. The method of claim 1, wherein compound is (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

4. The method of claim 1, wherein compound is (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione hydrochloride.

5. The method of any of claims 1-4, wherein the disease is systemic lupus erythematosus, scleroderma, lupus pernio, sarcoidosis, Sjögren syndrome, ANCA-induced vasculitis, anti-phospholipid syndrome or myasthenia gravis.

6. The method of any of claims 1-5, wherein the disease is systemic lupus erythematosus.

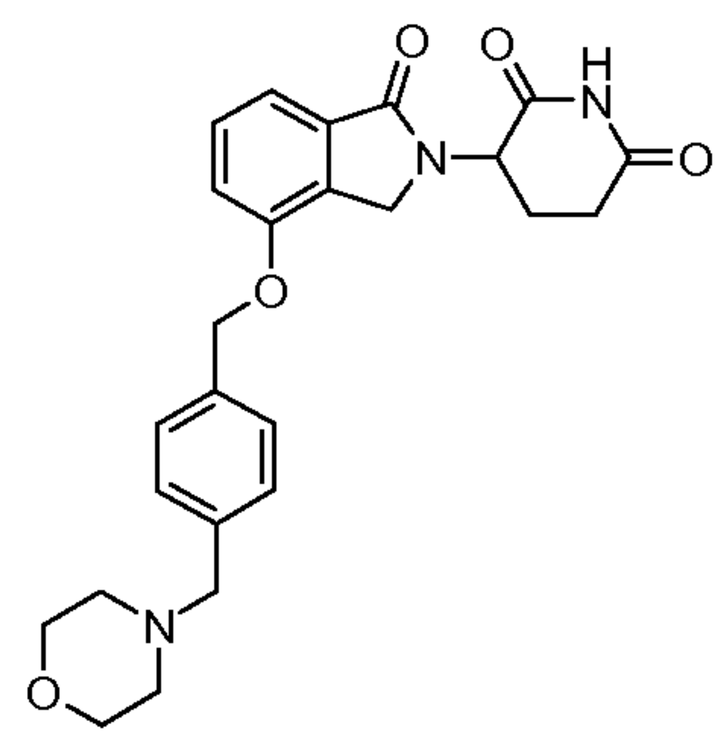
7. The method of any of claims 1-6, wherein disease is sever systemic lupus erythematosus.

8. The method of any of claims 1-4, wherein the disease is scleroderma.

9. The method of claim 8, wherein the scleroderma is localized, systemic, limited or diffuse scleroderma.

10. The method of claim 9, wherein the systemic scleroderma comprises CREST syndrome.

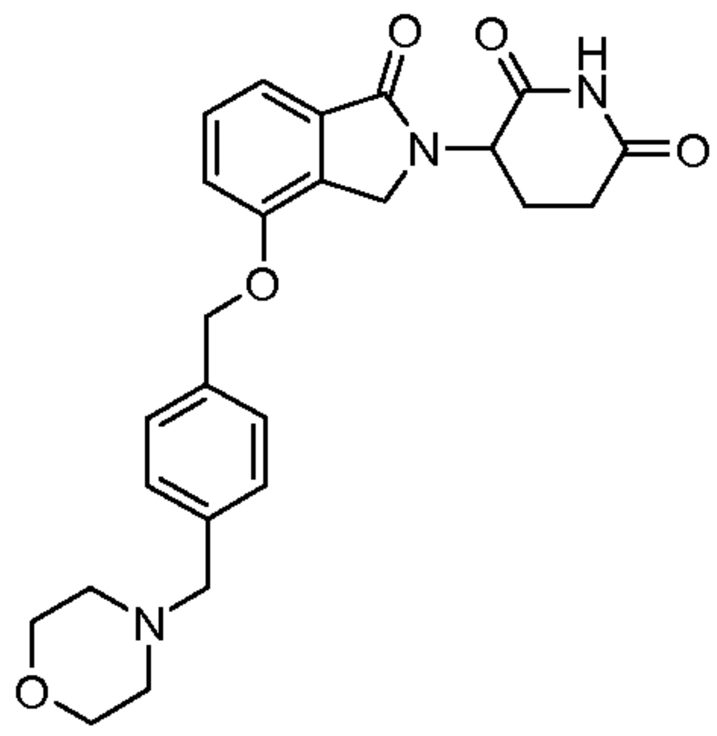
11. A method for reducing, inhibiting or preventing a symptom of systemic lupus erythematosus comprising administering to a patient having the symptom of systemic lupus erythematosus an effective amount of a compound, wherein the symptom is selected from the group consisting of joint pain, joint swelling, arthritis, chest pain when taking a deep breath, fatigue, fever with no other cause, general discomfort, uneasiness, hair loss, mouth sores, swollen lymph nodes, sensitivity to sunlight, skin rash, headaches, numbness, tingling, seizures, vision problems, personality changes, abdominal pain, nausea, vomiting, abnormal heart rhythms, coughing up blood and difficulty breathing, patchy skin color and Raynaud's phenomenon, and wherein the compound corresponds to formula I



I,

or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixture thereof.

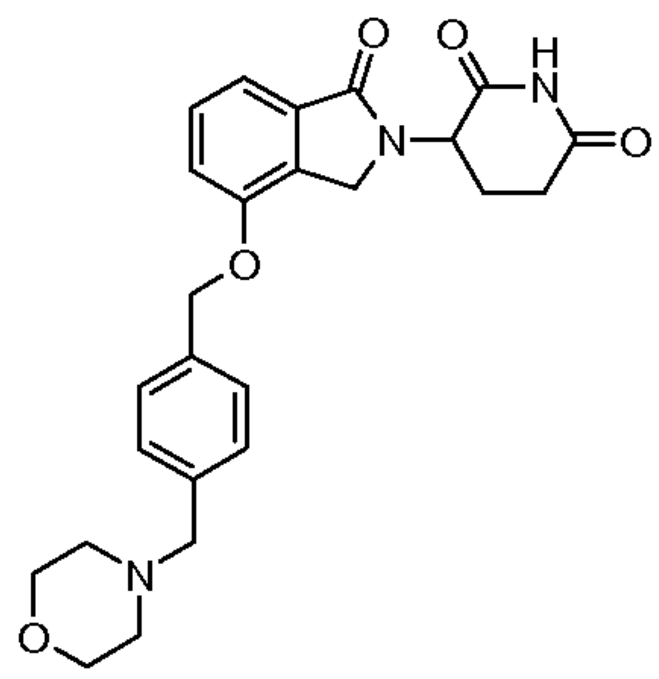
12. A method for reducing, inhibiting or preventing a symptom of scleroderma comprising administering to a patient having the symptom of scleroderma an effective amount of a compound, wherein the symptom is selected from the group consisting of (i) gradual hardening, thickening, and tightening of the skin; (ii) skin discoloration; (iii) numbness of extremities; (iv) shiny skin; (v) small white lumps under the surface of the skin that erupt into a chalky white fluid; (vi) Raynaud’s esophagaeal dysfunction; (vii) telangiectasia; (viii) pain and/or stiffness of the joints; (ix) swelling of the hands and feet; (x) itching of the skin; (xi) stiffening and curling of the fingers; (xii) ulcers on the outside of certain joints, such as knuckles and elbows; (xiii) digestive problems, such as heartburn, difficulty in swallowing, diarrhea, irritable bowel, and constipation; (xiv) fatigue and weakness; (xv) shortness of breath; (xvi) arthritis; (xvii) hair loss; (xviii) internal organ problems; (xix) digital ulcers; and (xx) digital auto-amputation, and wherein the compound corresponds to formula I



I,

or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixture thereof.

13. A method for improving the modified Rodnan skin score, reducing or improving the skin thickness, reducing or improving skin induration, improving the pulmonary function, improving the dermatology quality of life index, improving the carbon monoxide diffusing capacity, improving the Mahler Dyspnea index, improving the Saint George's Respiratory Questionnaire score, improving the UCLA scleroderma clinical trial consortium gastrointestinal tract score, improving flow-mediated dilatation or improving or increasing the six minute walk distance of a patient having scleroderma, comprising administering to the patient an effective amount of compound I having formula:



I,

or a pharmaceutically acceptable salt, solvate, hydrate, stereoisomer, tautomer or racemic mixture thereof.

14. The method of any of claims 11-13, wherein the compound is (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione or a pharmaceutically acceptable salt, solid form, solvate, hydrate, tautomer, stereoisomer or racemate thereof.

15. The method of any of claims 11-13, wherein compound is (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione.

16. The method of any of claims 11-13, wherein compound is (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione hydrochloride.

17. The method of any of claims 1-16 further comprising administering a second active agent is an anti-inflammatory or immunomodulatory compound.

18. The method of any of claims 1-17, wherein the effective amount is about 0.005 mg/kg to about 10 mg/kg of the patient's body weight.

19. A method for modulating activity of a B cell comprising contacting the cell with an effective amount of (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione or a pharmaceutically acceptable salt, solid form, solvate, hydrate, tautomer, stereoisomer or racemate thereof.

20. A method for modulating activity of a T cell comprising contacting the cell with an effective amount of (*S*)-3-[4-(4-morphlin-4-ylmethylbenzyloxy)-1-oxo-1,3-dihydro-isoindo-2-yl]piperidine-2,6-dione or a pharmaceutically acceptable salt, solid form, solvate, hydrate, tautomer, stereoisomer or racemate thereof.

21. A method of identifying a subject who is likely to be responsive to a treatment of a disease, disorder, or condition with a treatment compound, comprising:

a) determining the level of a biomarker in a biological sample from the subject, wherein the biomarker is CD44, CD83 or combination thereof; and

b) comparing the level of the biomarker in the biological sample from the subject to a reference level of the biomarker;

wherein the subject is likely to be responsive to the treatment if the level of the biomarker in the biological sample from the subject is altered as compared to the reference level of the biomarker.

22. A method of identifying a subject who is likely to be responsive to a treatment of a disease, disorder, or condition with a treatment compound, comprising:

a) determining the level of a biomarker in a biological sample from the subject, wherein the biomarker is CD44, CD83 or combination thereof;

b) determining the level of the biomarker in a control sample; and

c) comparing the level of the biomarker in the biological sample from the subject to the level of the biomarker in the control sample;

wherein the subject is likely to be responsive to the treatment if the level of the biomarker in the biological sample from the subject is altered as compared to the level of the biomarker in the control sample.

23. A method of predicting the responsiveness of a subject to a treatment of a disease, disorder, or condition with a treatment compound, comprising:

a) determining the level of a biomarker in a biological sample from the subject, wherein the biomarker is CD44, CD83 or combination thereof; and

b) comparing the level of the biomarker in the biological sample to a reference level of the biomarker;

wherein the difference between the level of the biomarker in the biological sample from the subject and the reference level of the biomarker correlates with the responsiveness of the subject to the treatment.

24. A method of predicting the responsiveness of a subject to a treatment of a disease, disorder, or condition with a treatment compound, comprising:

a) determining the level of a biomarker in a biological sample from the subject, wherein the biomarker is CD44, CD83 or combination thereof;

b) determining the level of the biomarker in a control sample; and

c) comparing the level of the biomarker in the biological sample from the subject to the level of the biomarker in the control sample;

wherein the difference between the level of the biomarker in the biological sample from the subject and the level of the biomarker in the control sample correlates with the responsiveness of the subject to the treatment.

25. A method of monitoring the efficacy of a treatment of a disease, disorder, or condition in a subject treated with a treatment compound, comprising:

a) obtaining a first biological sample from the subject;

b) determining the level of a biomarker in the first biological sample, wherein the biomarker is the CD44, CD83 or combination thereof;

c) administering the treatment compound to the subject;

d) thereafter obtaining a second biological sample from the subject;

e) determining the level of the biomarker in the second biological sample, and

f) comparing the levels of the biomarker in the first and second biological samples;

wherein the subject is responsive to the treatment if the level of the biomarker in the second biological sample of the subject is altered as compared to the level of the biomarker in the first biological sample of the subject.

26. A method of monitoring the compliance of a subject with a treatment of a disease, disorder, or condition with a treatment compound, comprising:

a) obtaining a biological sample from the subject;

b) determining the level of a biomarker in the biological sample, wherein the biomarker is CD44, CD83 or combination thereof; and

c) comparing the level of the biomarker with the level of the biomarker in a control untreated sample from the subject;

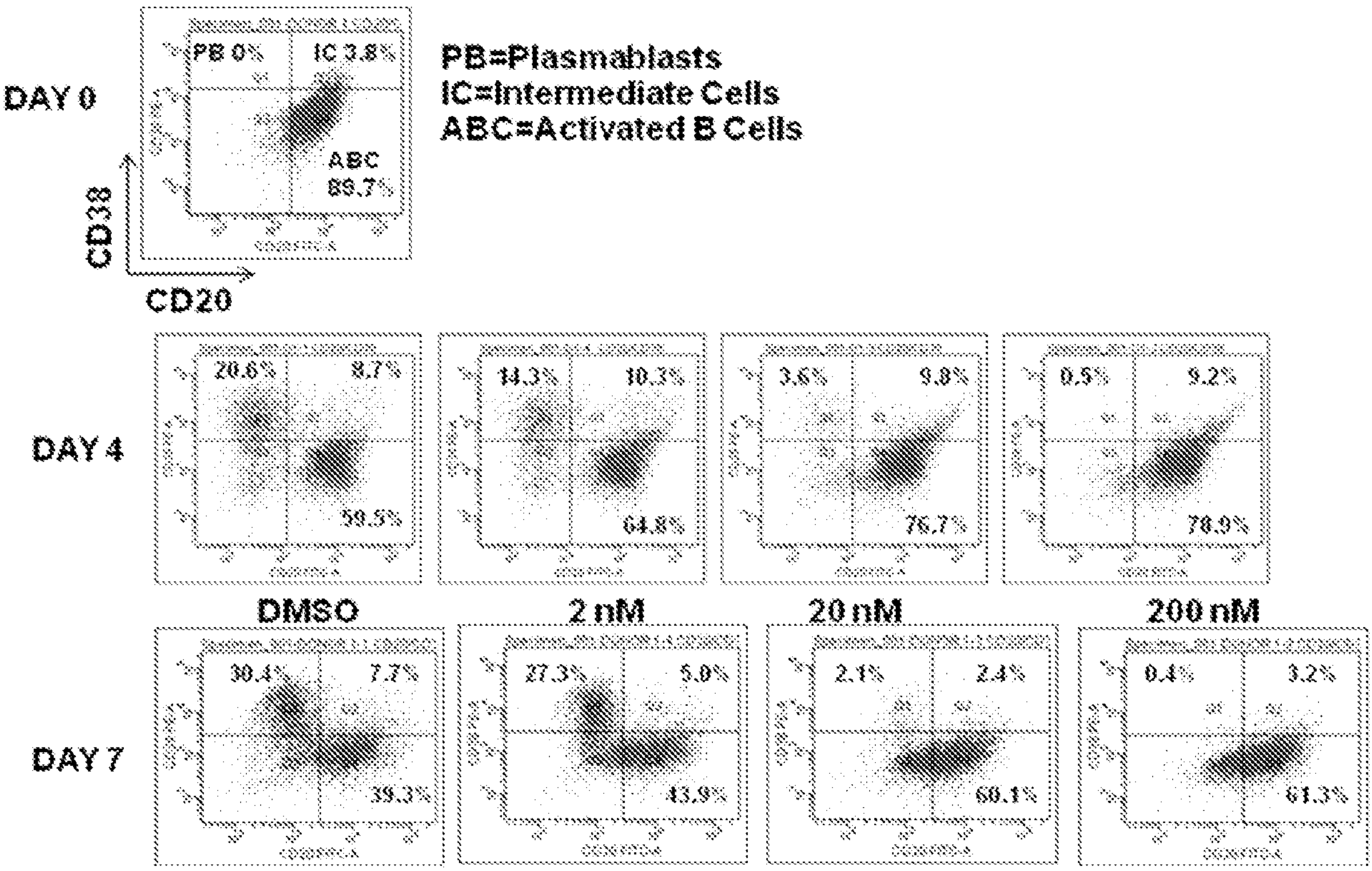
wherein the change in the level of the biomarker in the biological sample in comparison with the level of the biomarker in the control sample indicates the compliance of the subject with the treatment.

27. The method of any of claims 21 to 36, wherein the treatment compound is an immunomodulatory compound.

28. The method of claim 27, wherein the treatment compound is (*S*)-3-(4-((4-(morpholinomethyl)benzyl)oxy)-1-oxoisoindolin-2-yl)piperidine-2,6-dione.

29. The method of claim 28, wherein the treatment compound is (*S*)-3-(4-((4-(morpholinomethyl)benzyl)oxy)-1-oxoisoindolin-2-yl)piperidine-2,6-dione.

FIG. 1


PB=Plasmablasts
IC=Intermediate Cells
ABC=Activated B Cells
DAY 0
PB 0%
IC 3.8%
ABC 89.7%
CD38
CD20
DAY 4
20.6%
8.7%
59.5%
14.3%
10.3%
64.8%
3.6%
9.8%
76.7%
0.5%
9.2%
78.9%
DMSO
2 nM
20 nM
200 nM
DAY 7
30.4%
7.7%
39.3%
27.3%
5.0%
43.9%
2.1%
2.4%
60.1%
0.4%
3.2%
61.3%

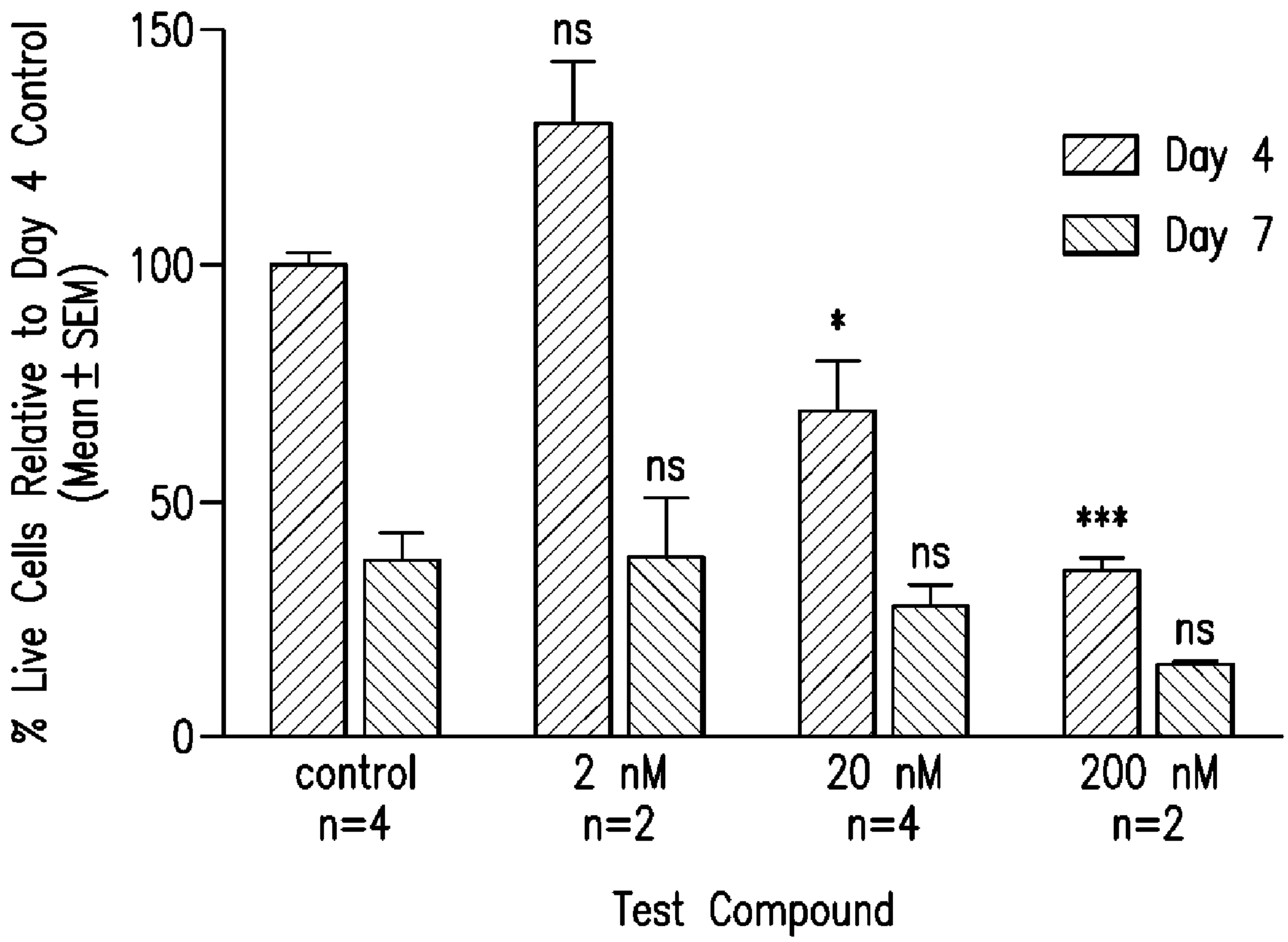

% Live Cells Relative to Day 4 Control
(Mean ± SEM)
150
100
50
0
ns
ns
*
ns
***
ns
Day 4
Day 7
control
n=4
2 nM
n=2
20 nM
n=4
200 nM
n=2
Test Compound

FIG. 2

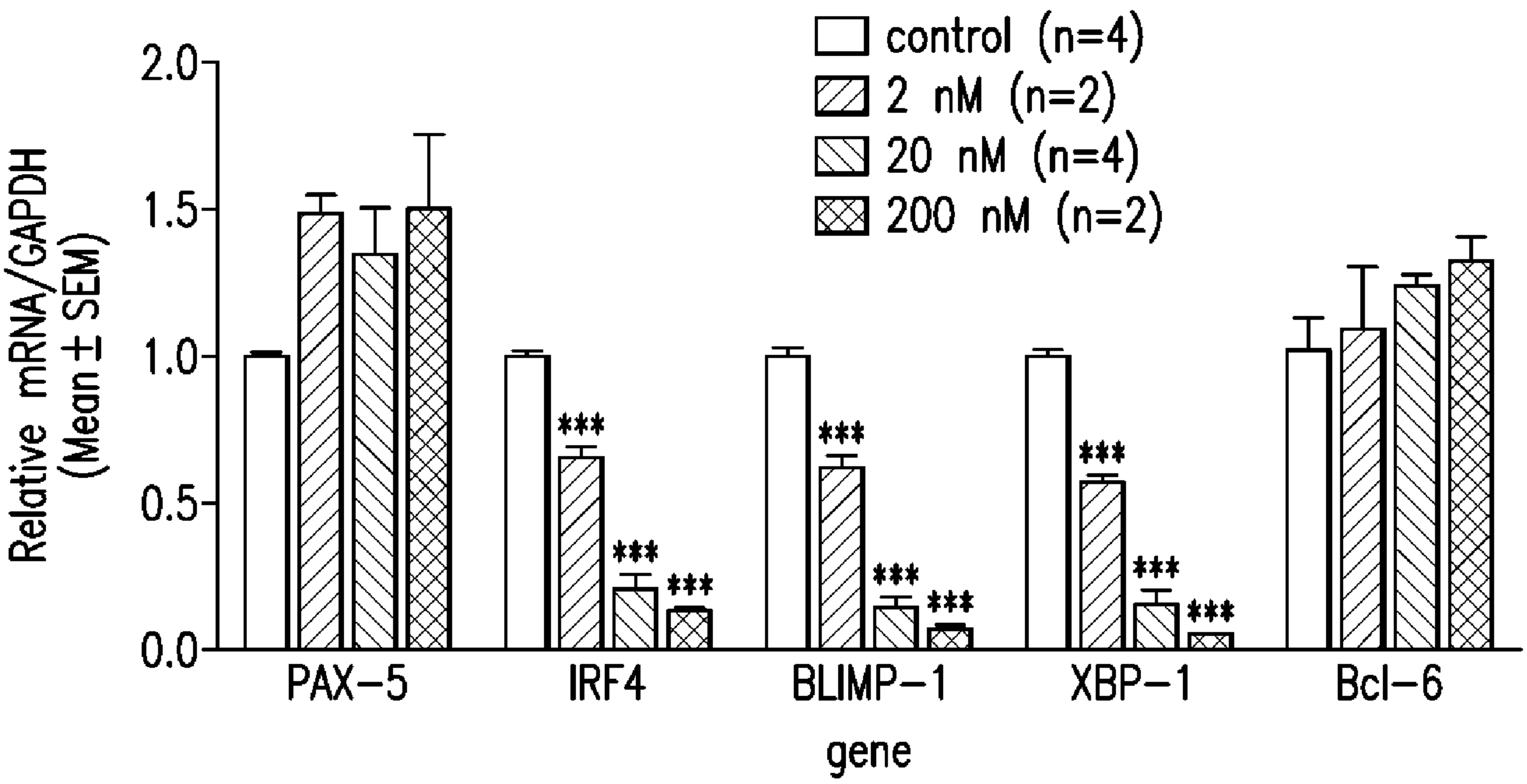

control (n=4)
2 nM (n=2)
20 nM (n=4)
200 nM (n=2)
Relative mRNA/GAPDH (Mean ± SEM)
2.0
1.5
1.0
0.5
0.0
***
PAX-5
IRF4
BLIMP-1
XBP-1
Bcl-6
gene

FIG. 3

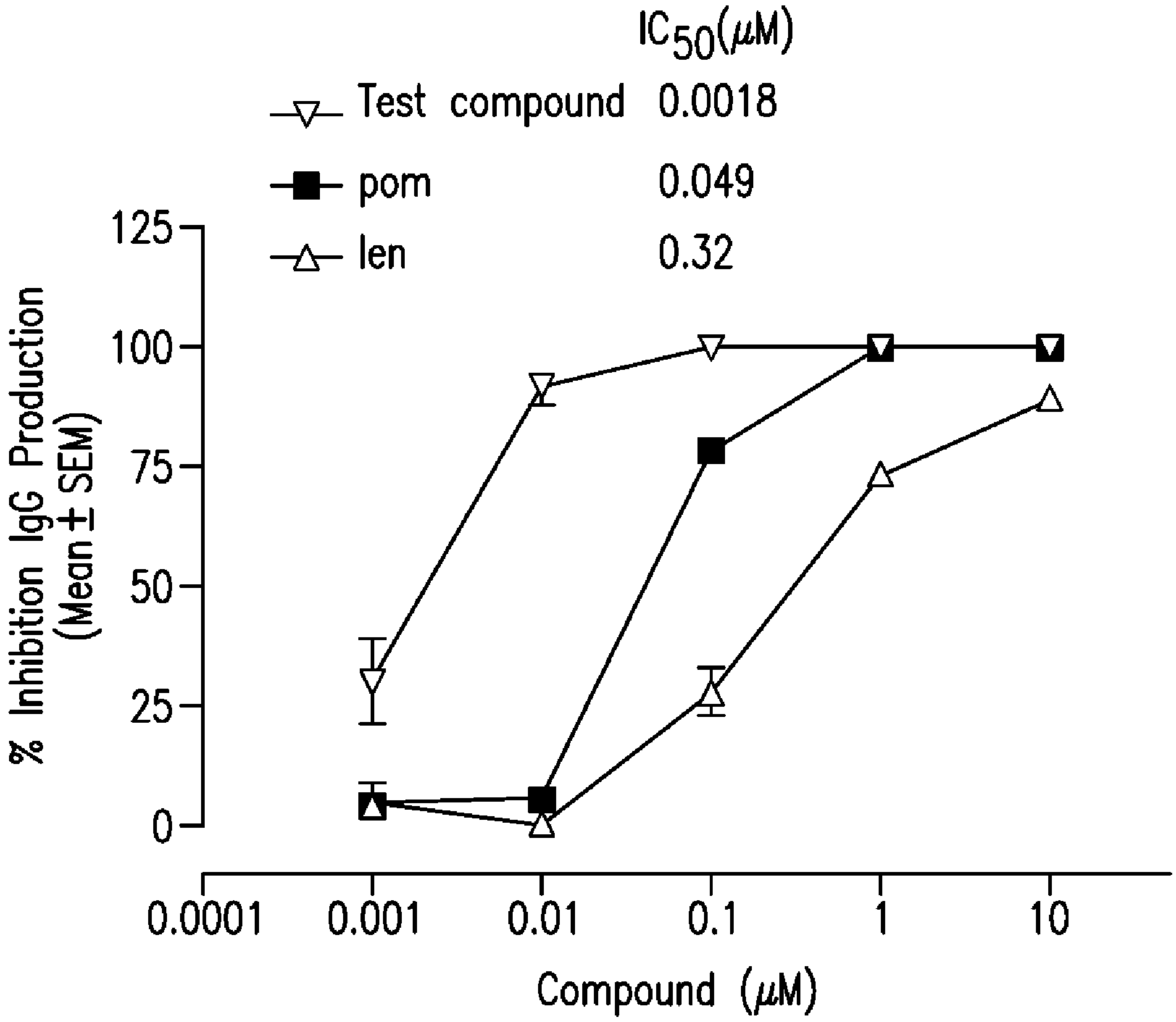

IC50(µM)
Test compound 0.0018
pom 0.049
len 0.32
125
100
75
50
25
0
% Inhibition IgG Production
(Mean ± SEM)
0.0001
0.001
0.01
0.1
1
10
Compound (µM)

FIG. 4

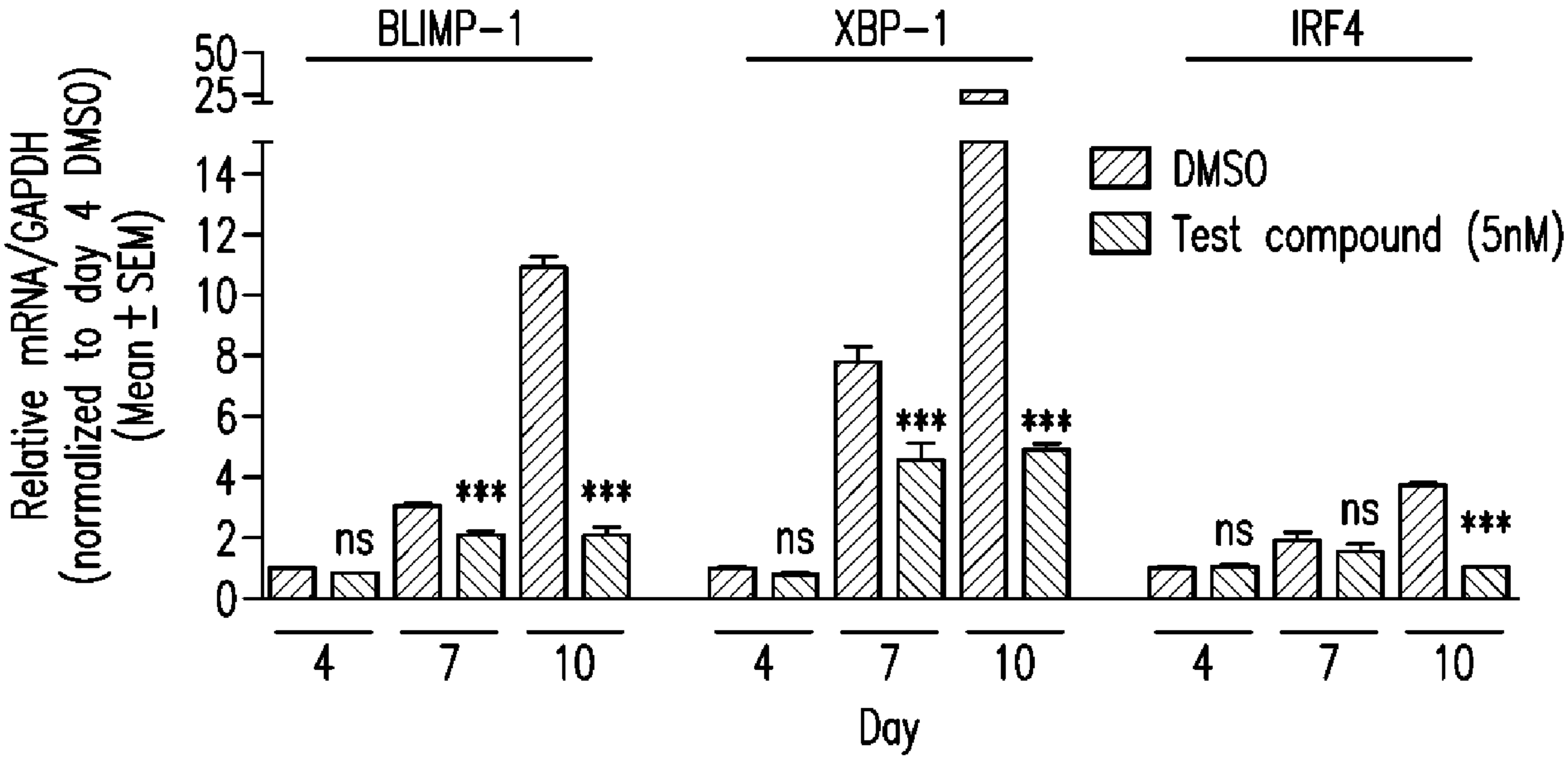

BLIMP-1
XBP-1
IRF4
Relative mRNA/GAPDH
(normalized to day 4 DMSO)
(Mean ± SEM)
50
25
14
12
10
8
6
4
2
0
DMSO
Test compound (5nM)
ns
***
4
7
10
Day

FIG. 5A

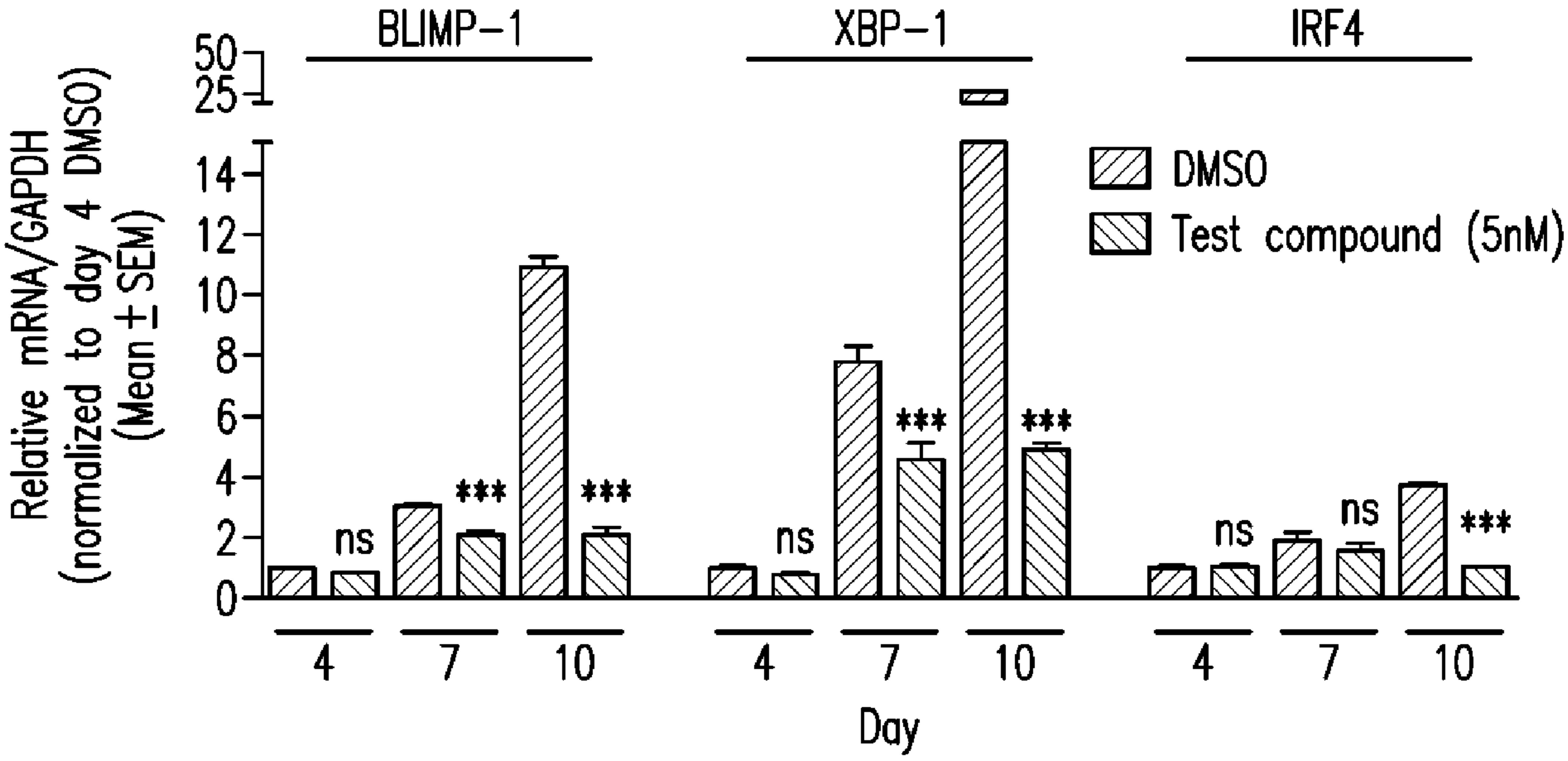

BLIMP-1
XBP-1
IRF4
Relative mRNA/GAPDH
(normalized to day 4 DMSO)
(Mean ± SEM)
50
25
14
12
10
8
6
4
2
0
DMSO
Test compound (5nM)
ns
***
4
7
10
Day

FIG. 5B

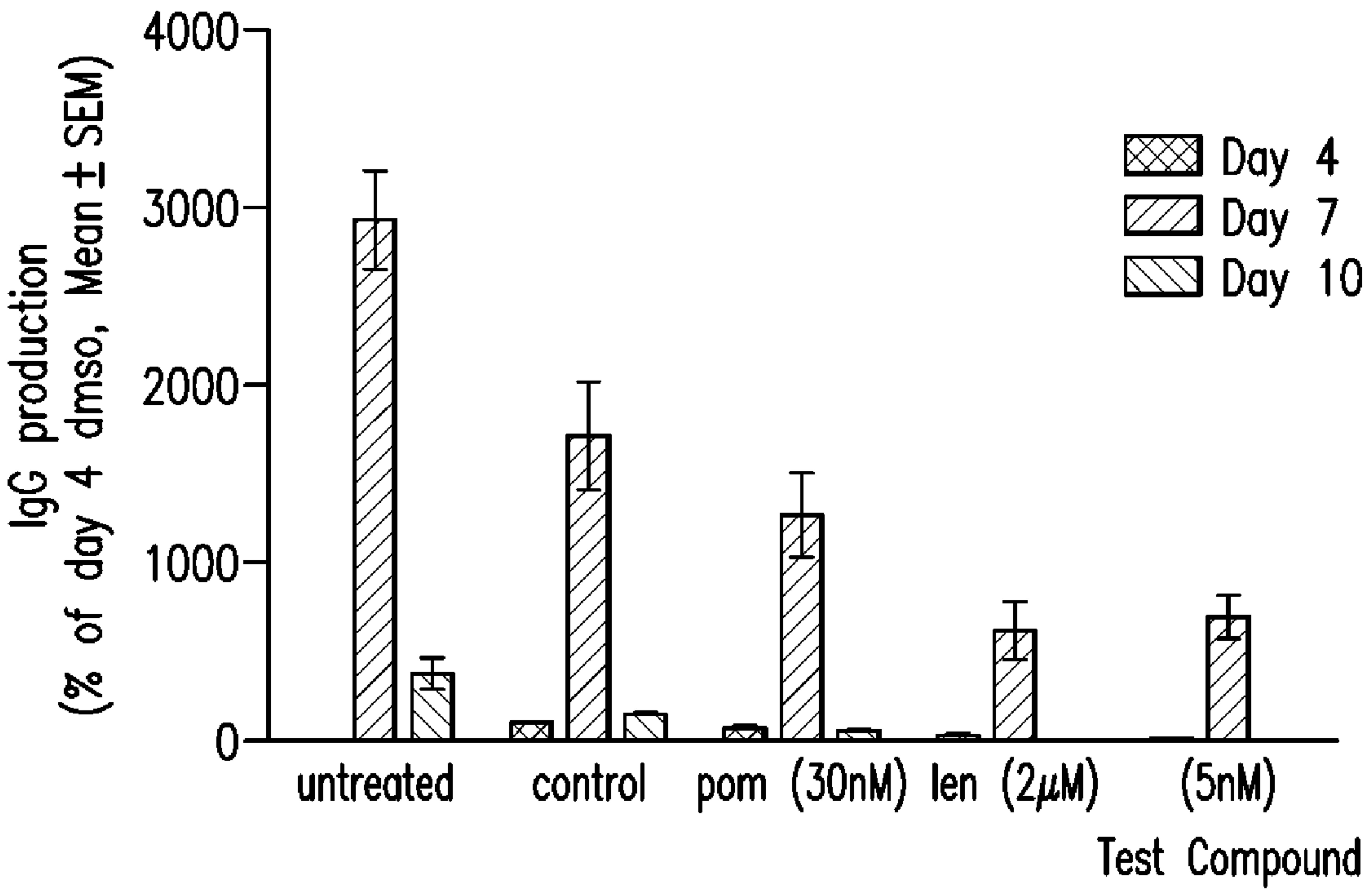

IgG production
(% of day 4 dmso, Mean ± SEM)
4000
3000
2000
1000
0
Day 4
Day 7
Day 10
untreated
control
pom (30nM)
len (2μM)
(5nM)
Test Compound

FIG. 6

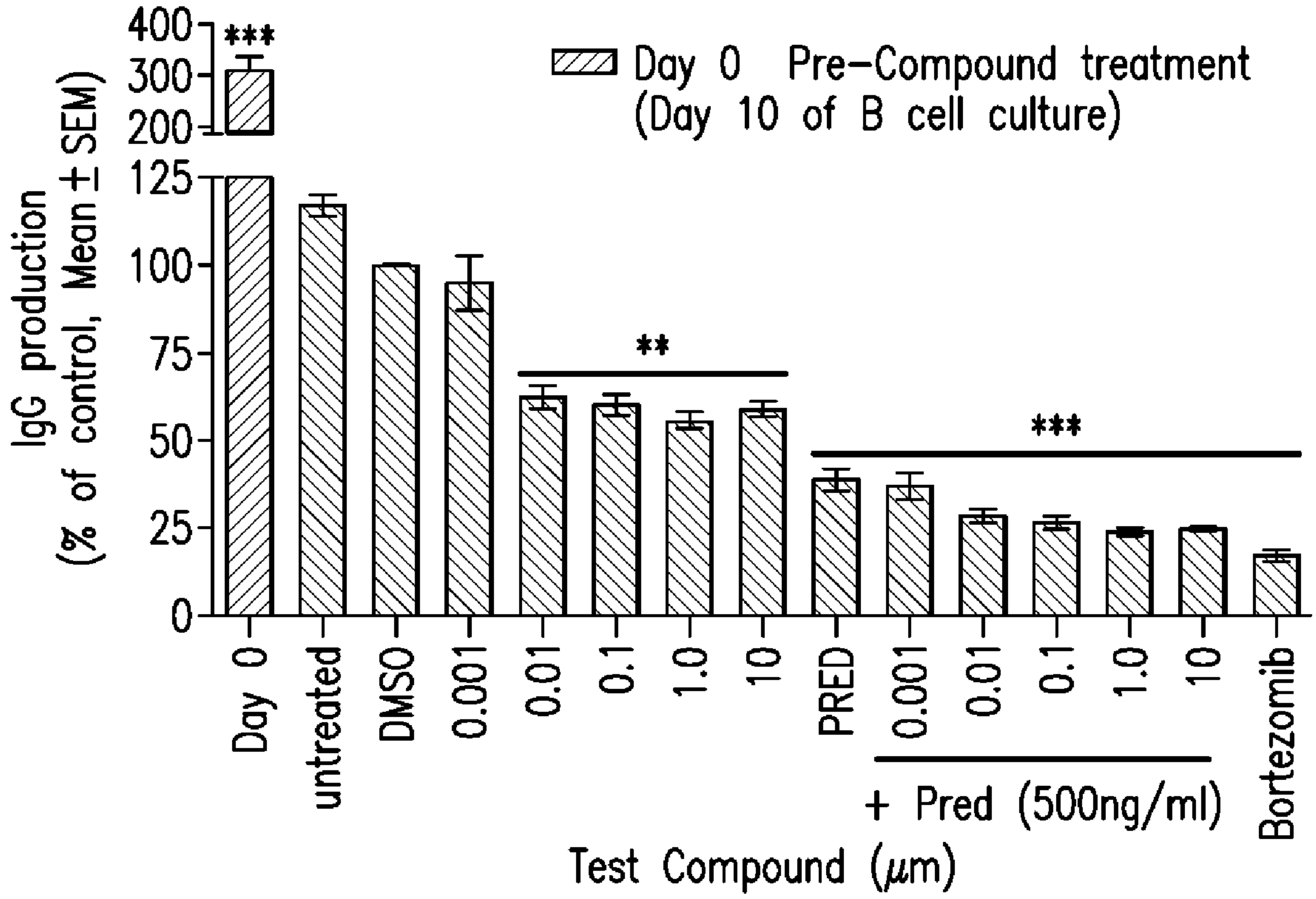
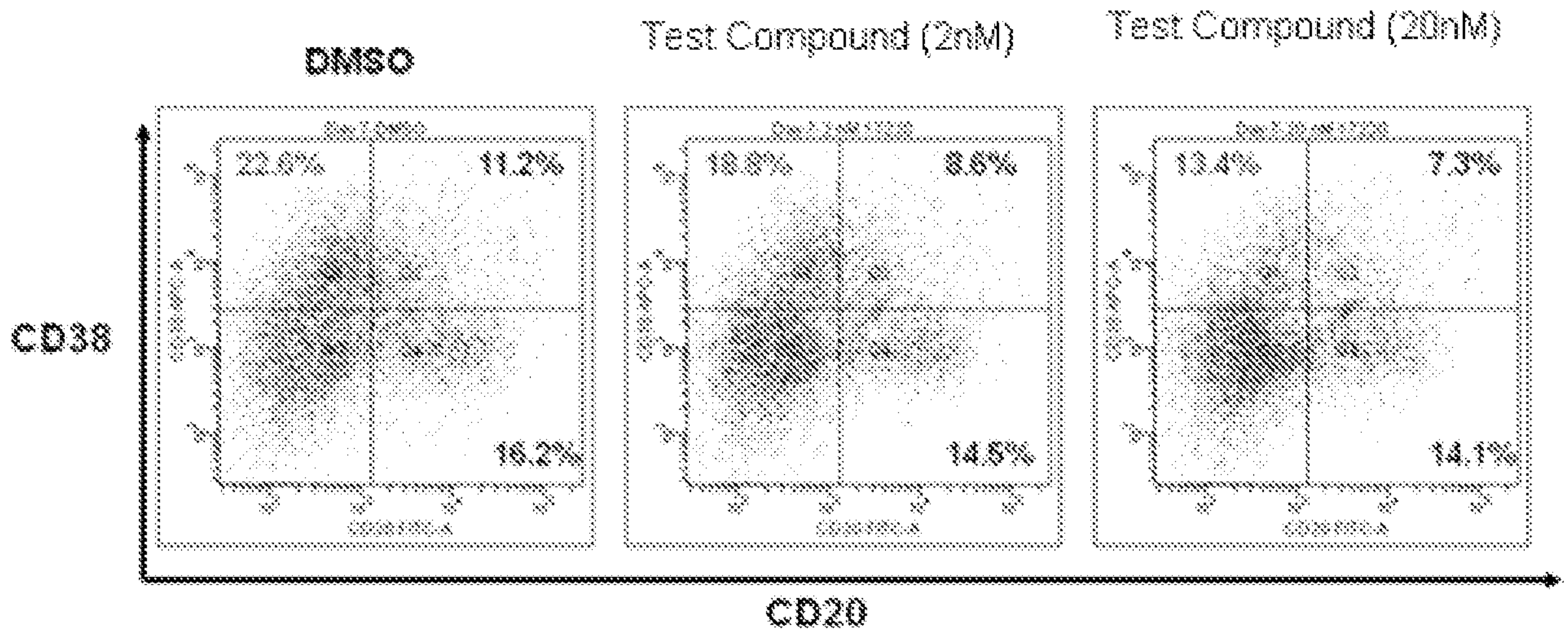

Day 0 Pre-Compound treatment
(Day 10 of B cell culture)
IgG production
(% of control, Mean ± SEM)
400
300
200
125
100
75
50
25
0
***
**
***
Day 0
untreated
DMSO
0.001
0.01
0.1
1.0
10
PRED
0.001
0.01
0.1
1.0
10
+ Pred (500ng/ml)
Bortezomib
Test Compound (μm)

FIG. 7

FIG. 8


DMSO
Test Compound (2nM)
Test Compound (20nM)
CD38
CD20
22.0%
11.2%
16.2%
18.8%
8.6%
14.5%
13.4%
7.3%
14.1%

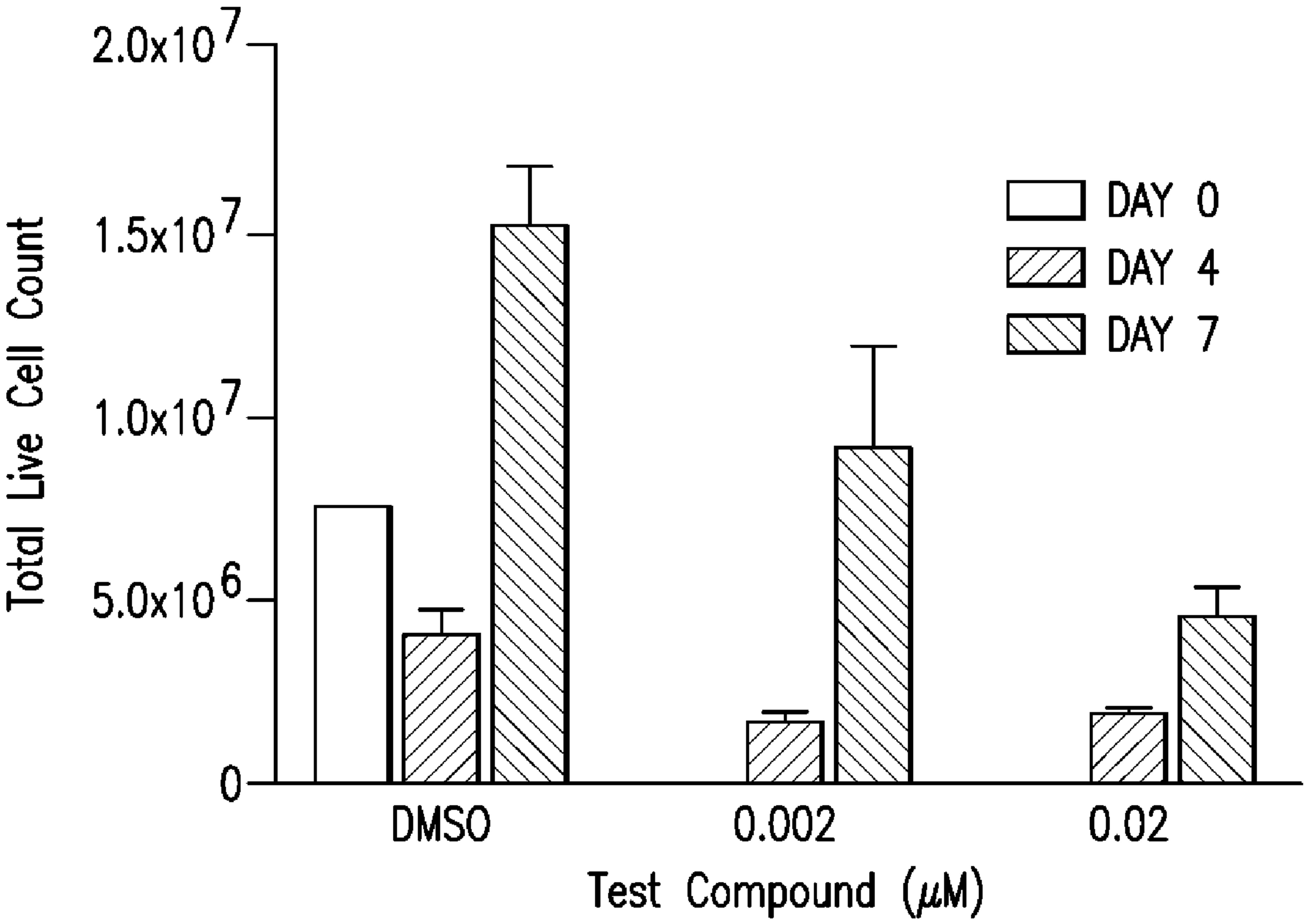

2.0x10^7
1.5x10^7
1.0x10^7
5.0x10^6
0
Total Live Cell Count
DAY 0
DAY 4
DAY 7
DMSO
0.002
0.02
Test Compound (μM)

FIG. 9

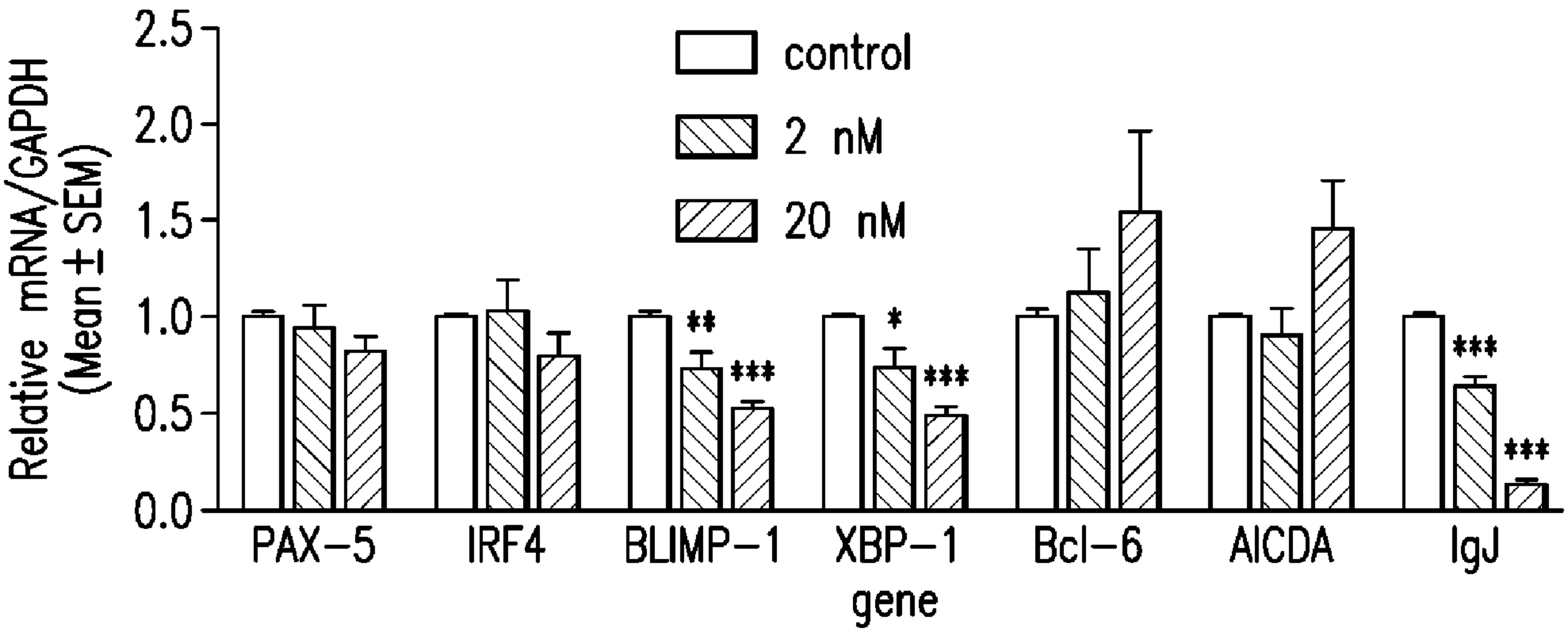

2.5
2.0
1.5
1.0
0.5
0.0
Relative mRNA/GAPDH (Mean ± SEM)
control
2 nM
20 nM
**
***
*
***
***
***
PAX-5
IRF4
BLIMP-1
XBP-1
Bcl-6
AICDA
IgJ
gene

FIG. 10

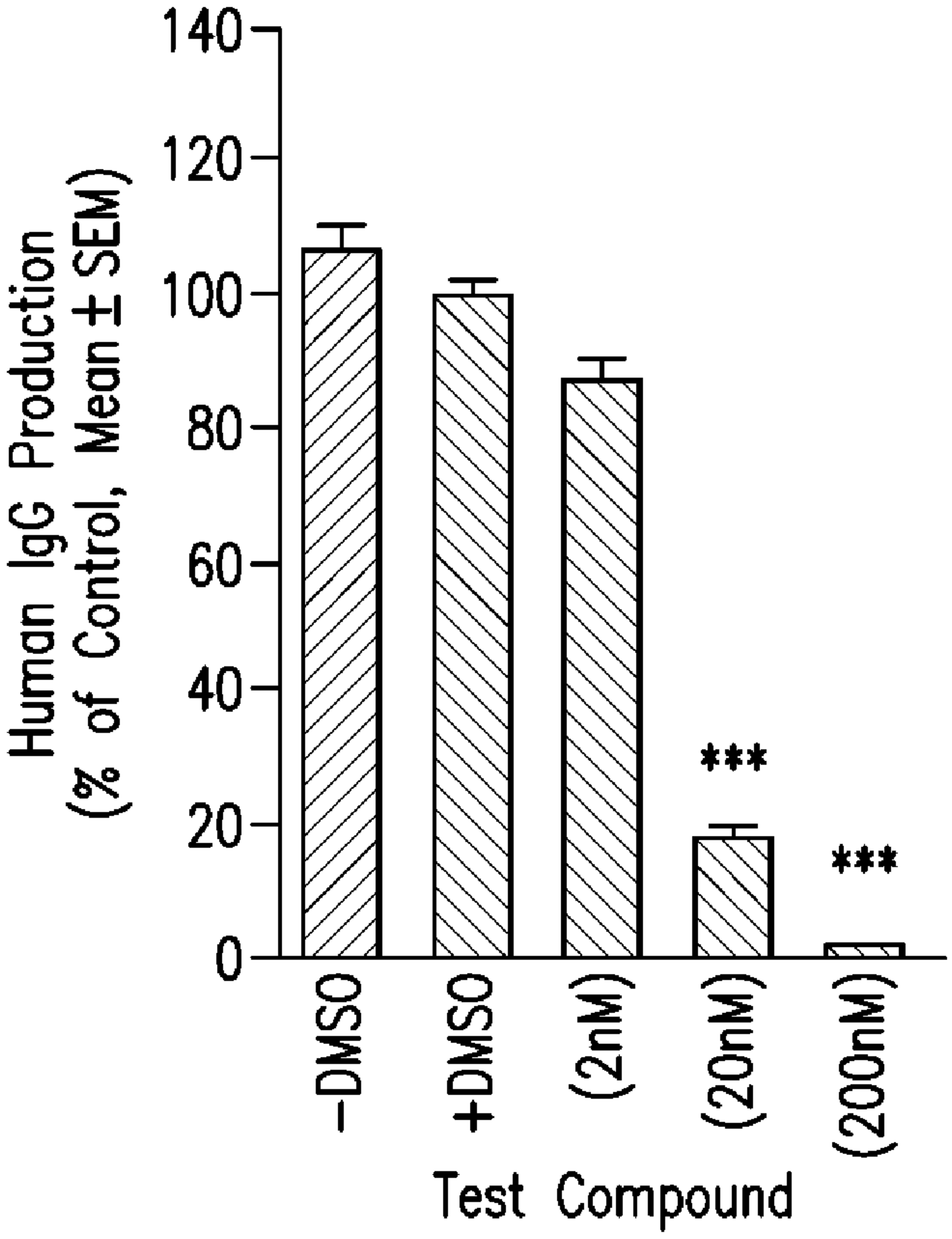


FIG. 11A

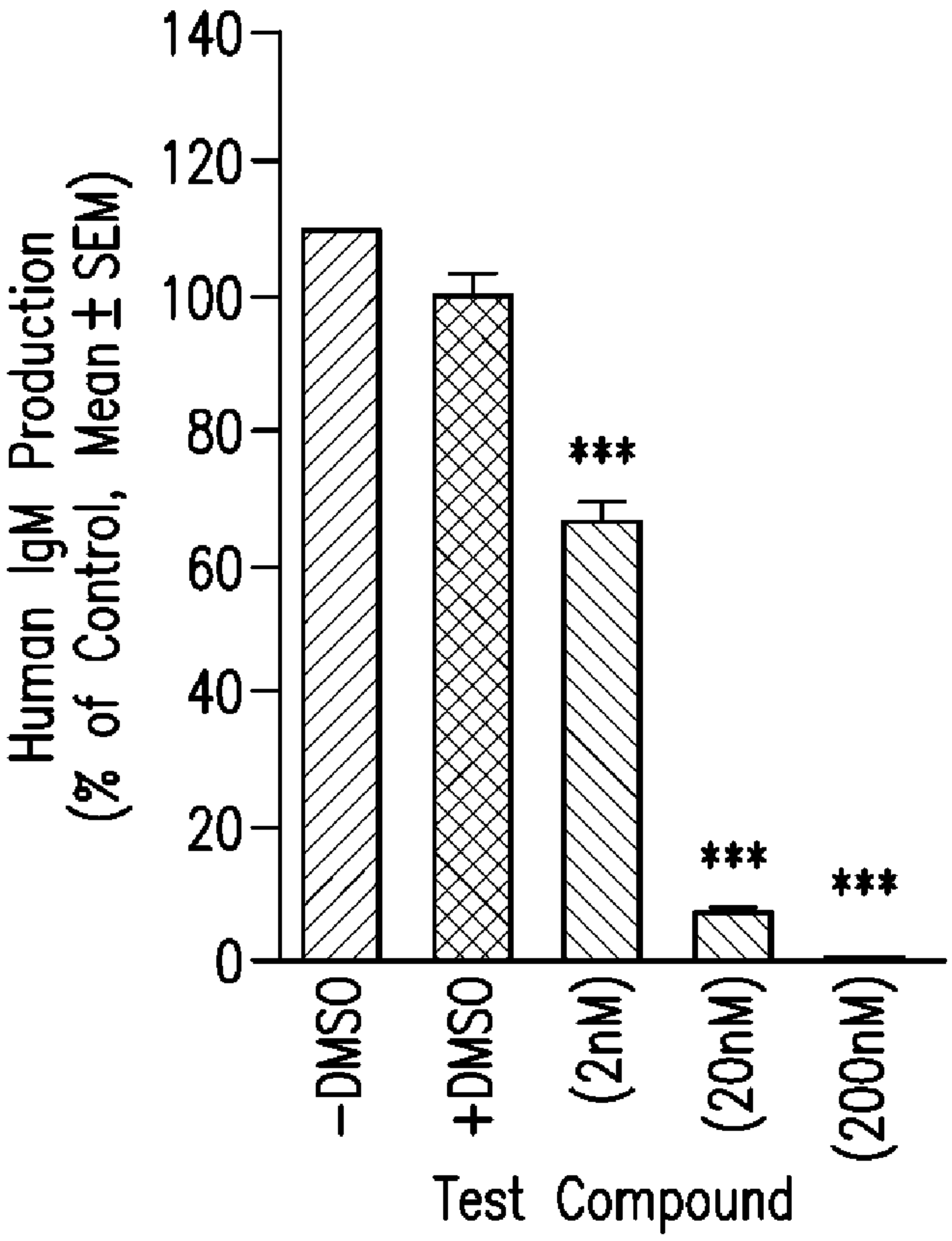


FIG. 11B

FIG. 12A

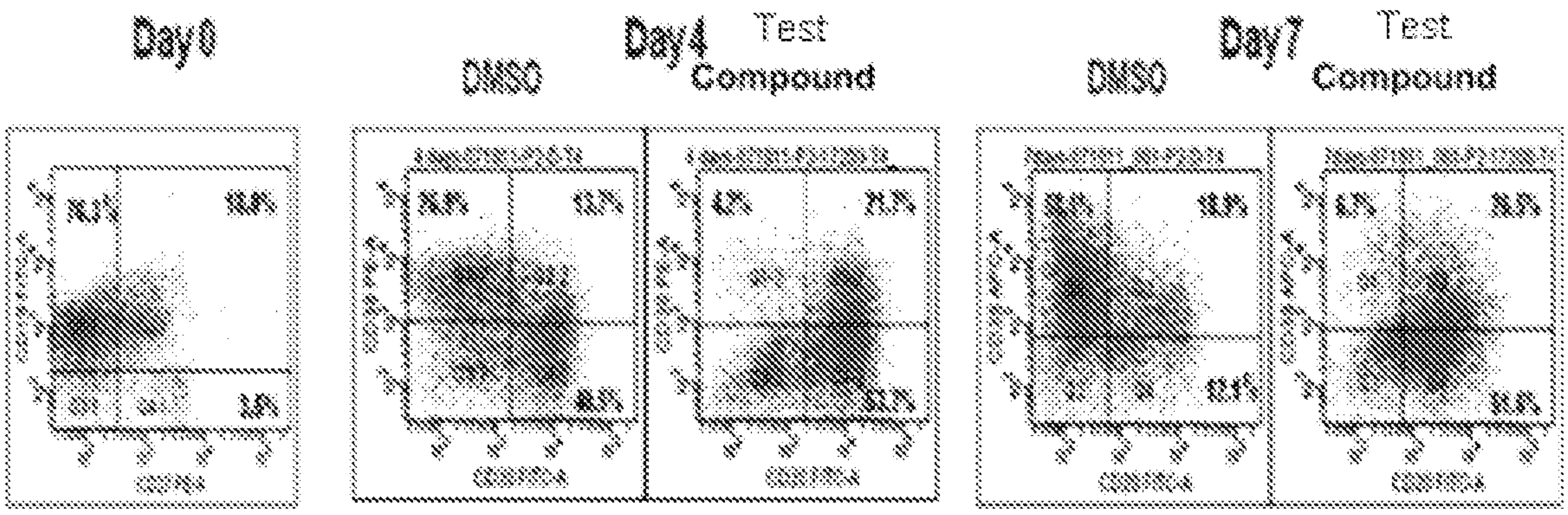


FIG. 12B

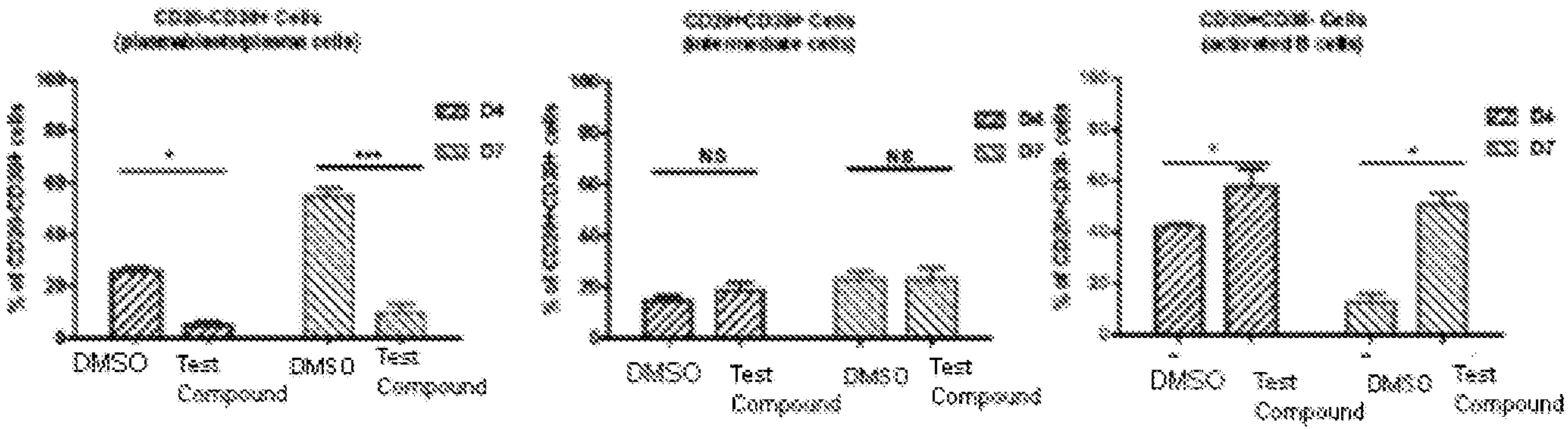


FIG. 13

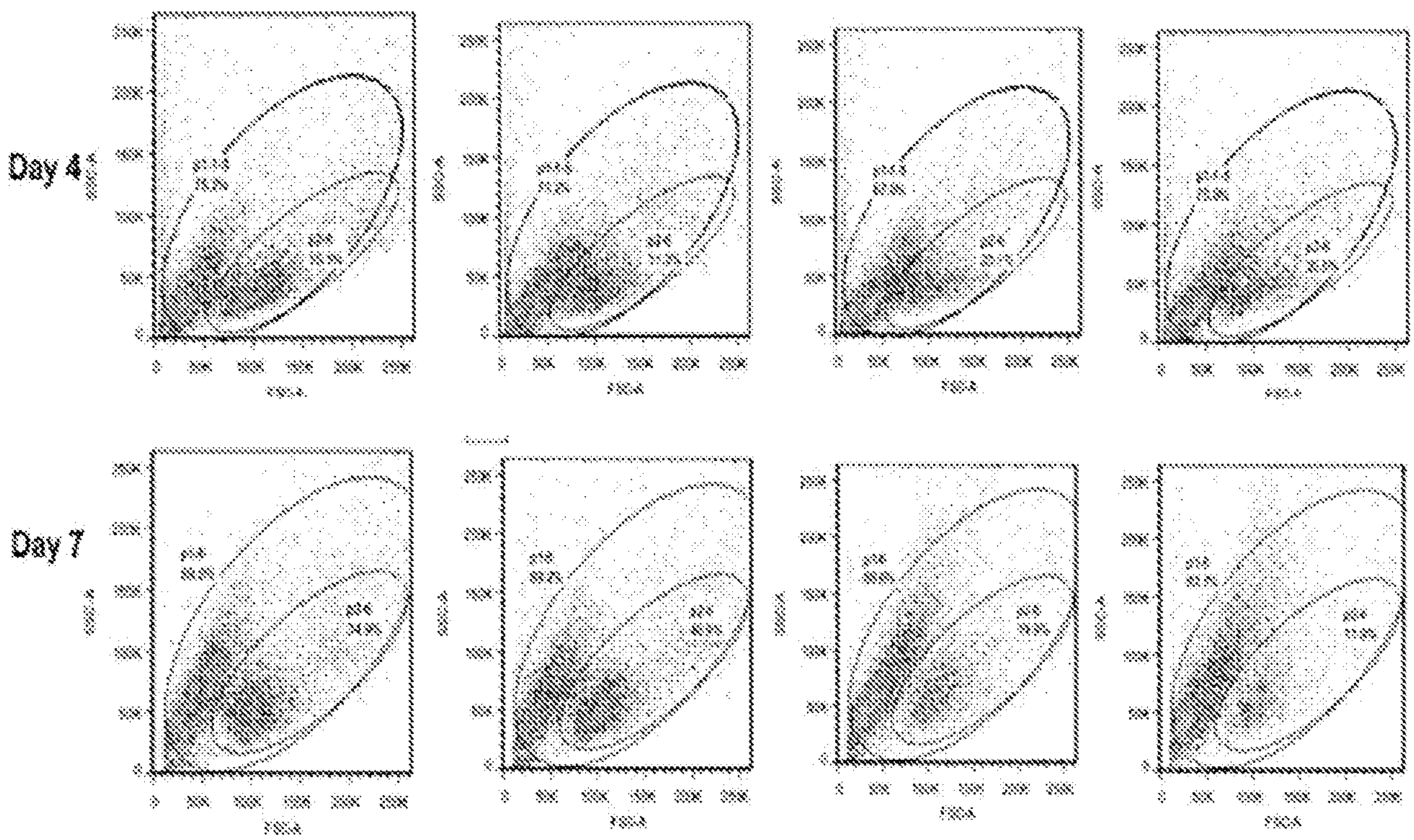
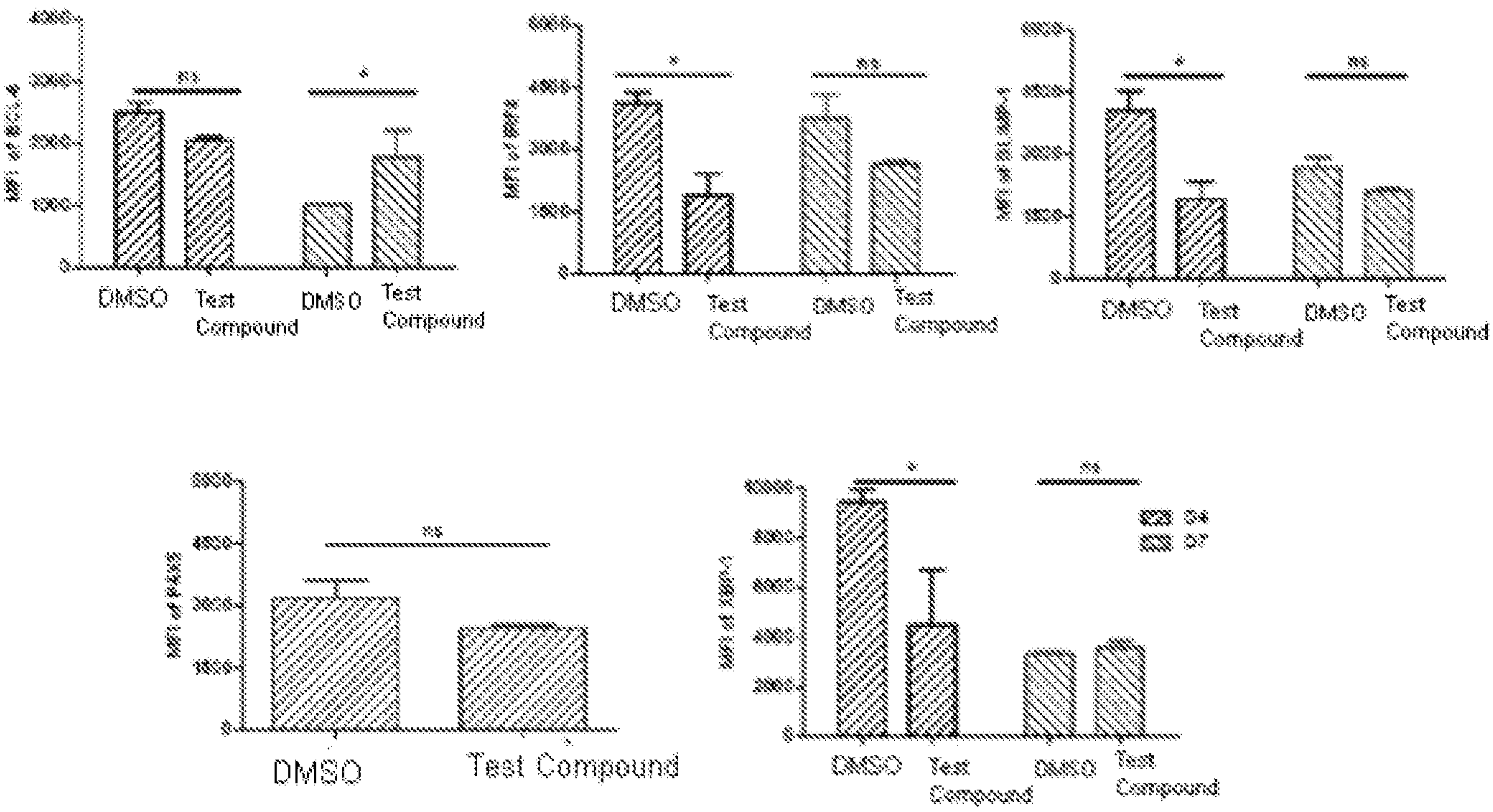
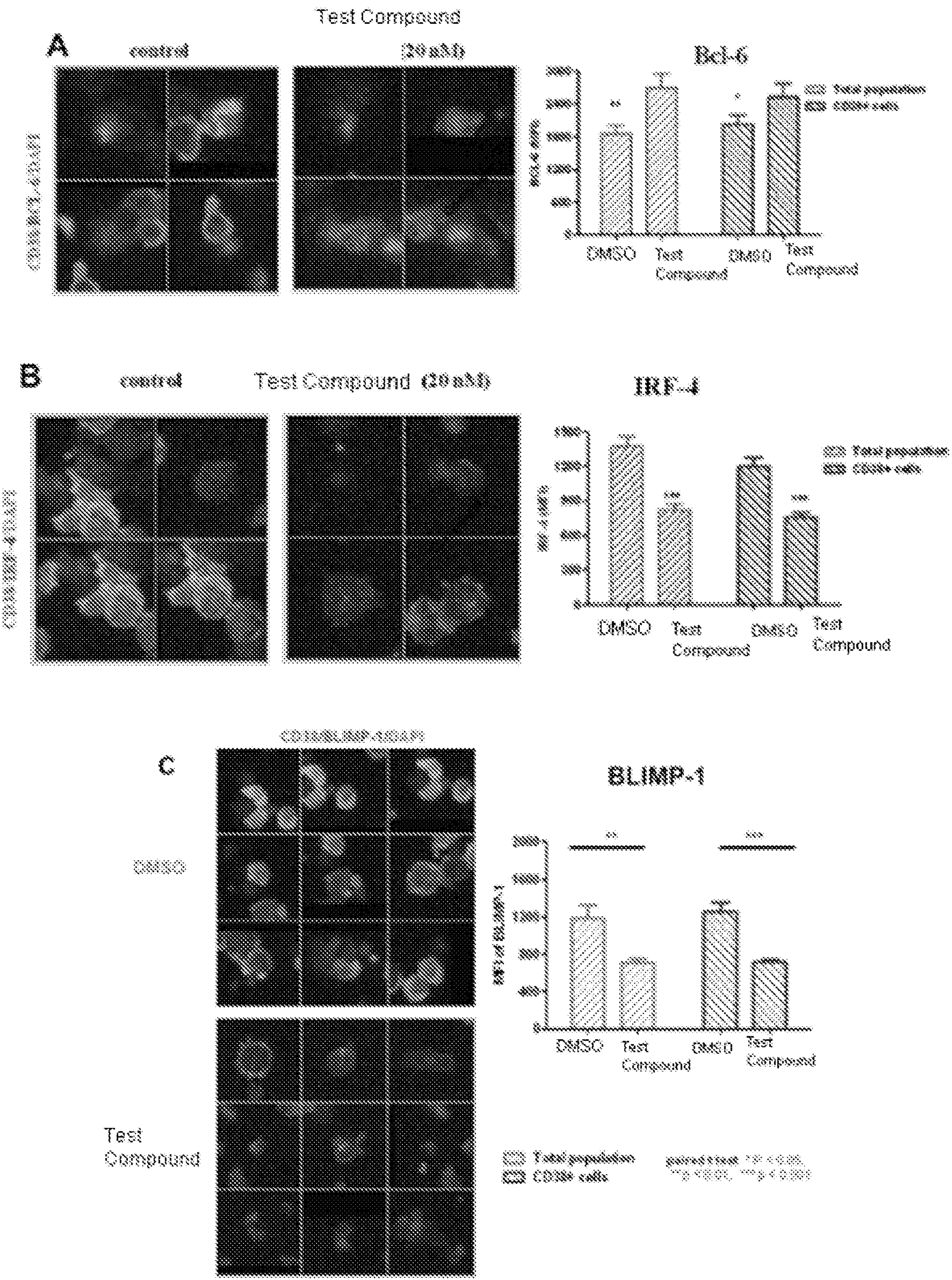


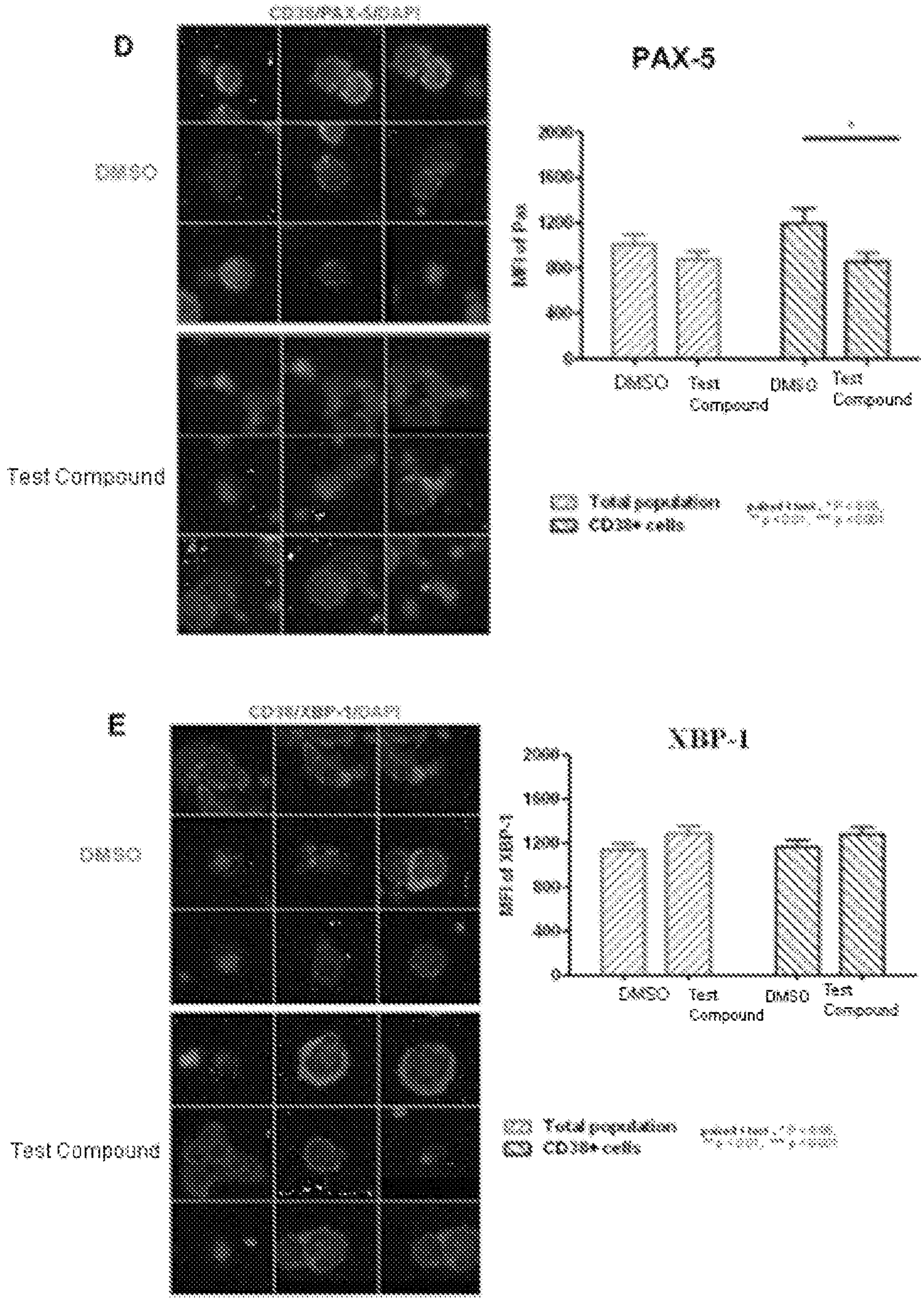
FIG. 14


DMSO
Test Compound
DMSO
Test Compound
DMSO
Test Compound
DMSO
Test Compound
DMSO
Test Compound
DMSO
Test Compound
DMSO
Test Compound
DMSO
Test Compound
DMSO
Test Compound

FIGs. 15A, 15B and 15C



FIGs. 15D and 15E



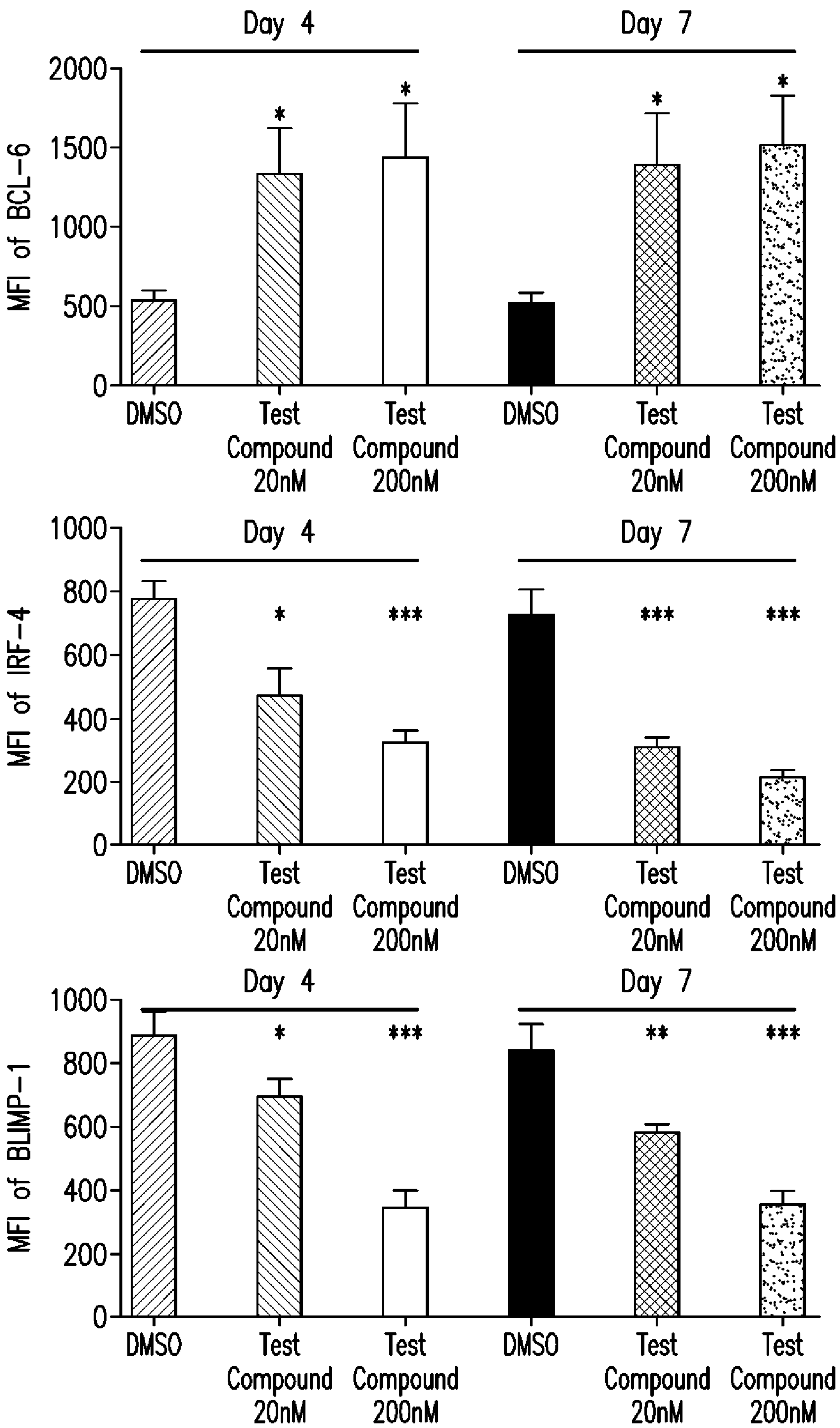

Day 4
Day 7
2000
1500
1000
500
0
MFI of BCL-6
*
*
*
*
DMSO
Test Compound 20nM
Test Compound 200nM
DMSO
Test Compound 20nM
Test Compound 200nM
Day 4
Day 7
1000
800
600
400
200
0
MFI of IRF-4
*
***
***
***
DMSO
Test Compound 20nM
Test Compound 200nM
DMSO
Test Compound 20nM
Test Compound 200nM
Day 4
Day 7
1000
800
600
400
200
0
MFI of BLIMP-1
*
***
**
***
DMSO
Test Compound 20nM
Test Compound 200nM
DMSO
Test Compound 20nM
Test Compound 200nM

FIG. 16

FIG. 17

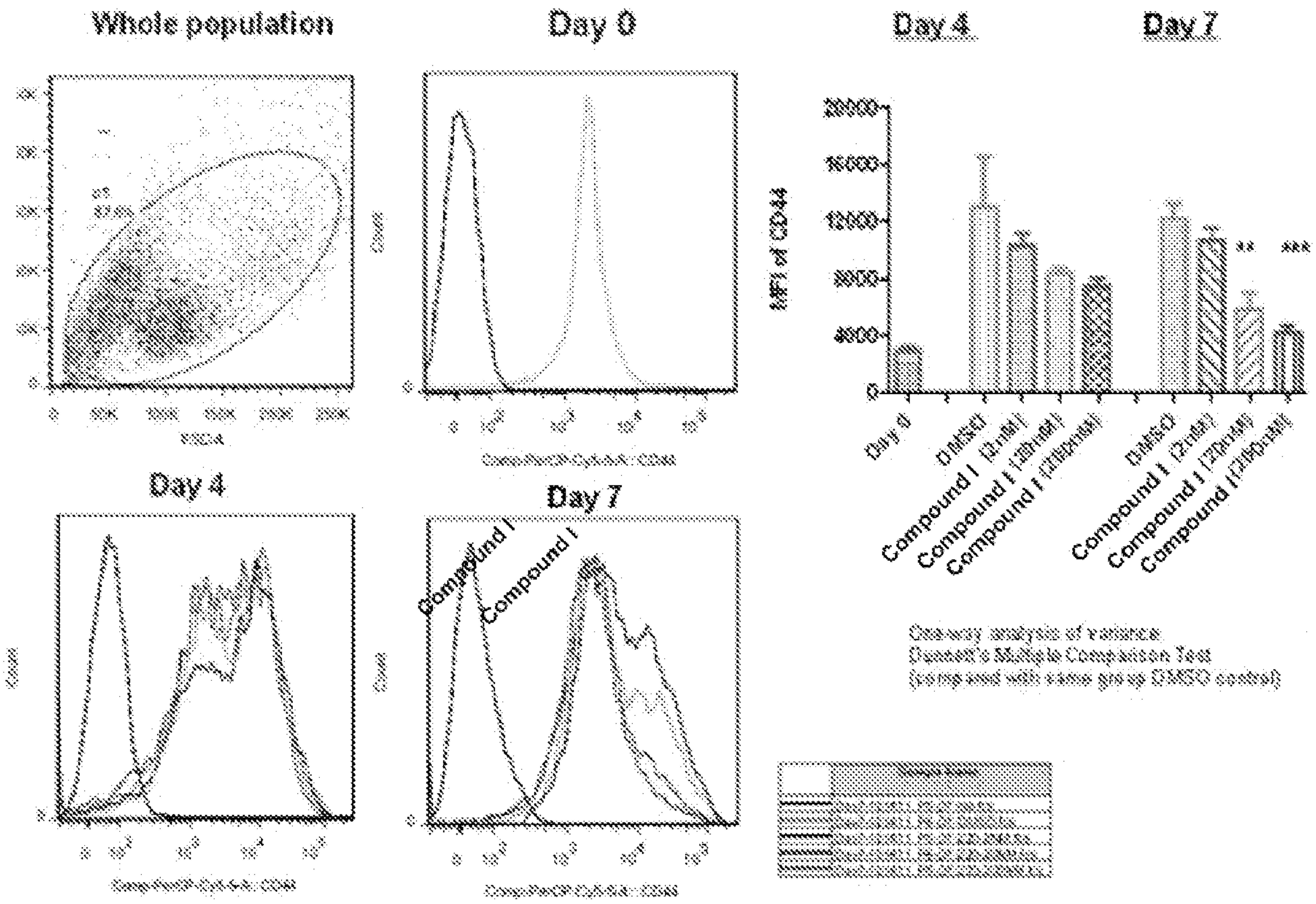

Whole population
Day 0
Day 4
Day 7
MFI of CD44
20000
16000
12000
8000
4000
0
Day 0
DMSO
Compound I (2nM)
Compound I (20nM)
Compound I (200nM)
Compound I (2000nM)
**
***
Compound I
One-way analysis of variance
Dunnett's Multiple Comparison Test
(compared with same group DMSO control)
Count

FIG. 18

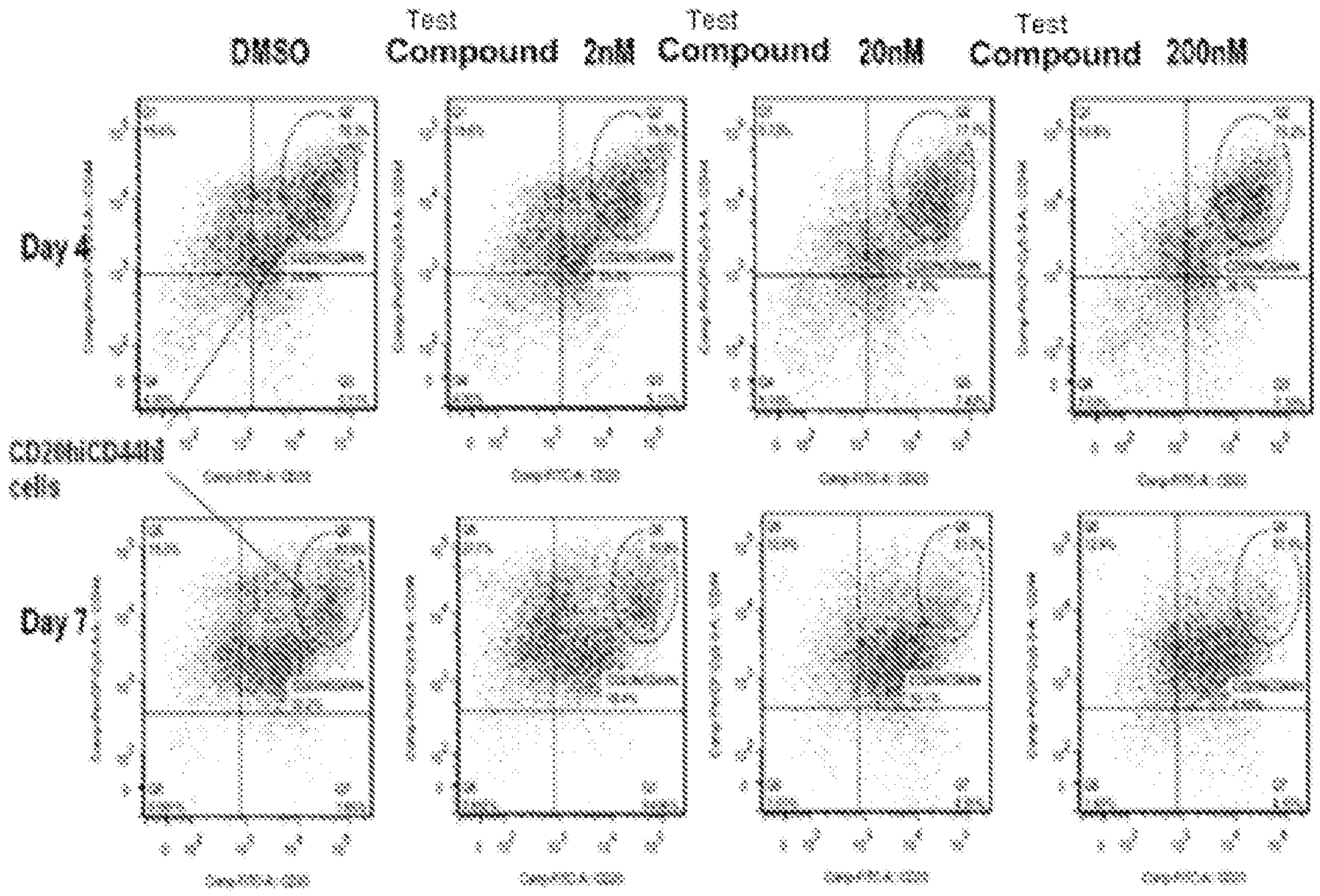

Test
DMSO
Compound 2nM
Compound 20nM
Compound 200nM
Day 4
Day 7
CD20hiCD44hi cells

FIG. 19

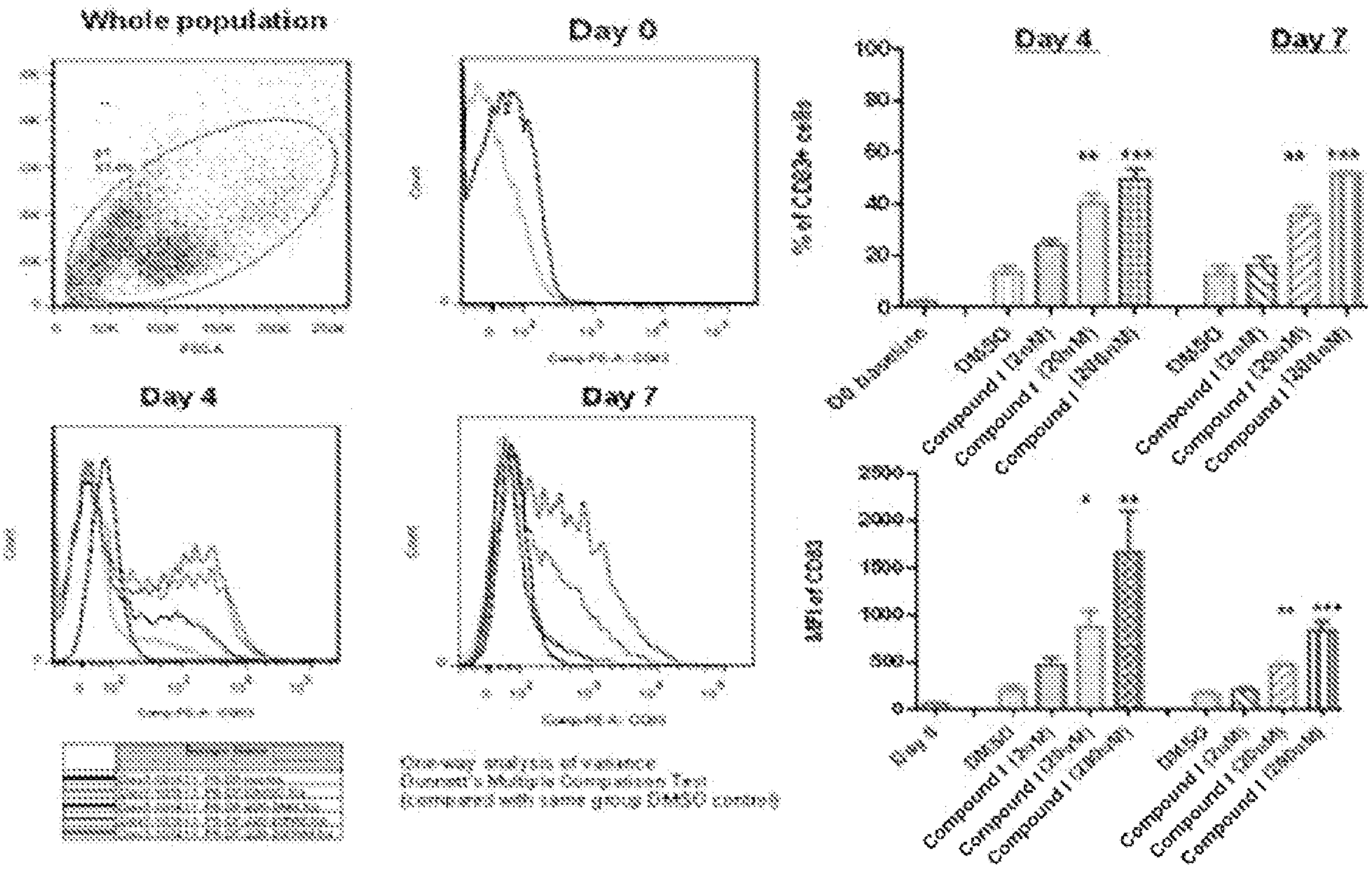
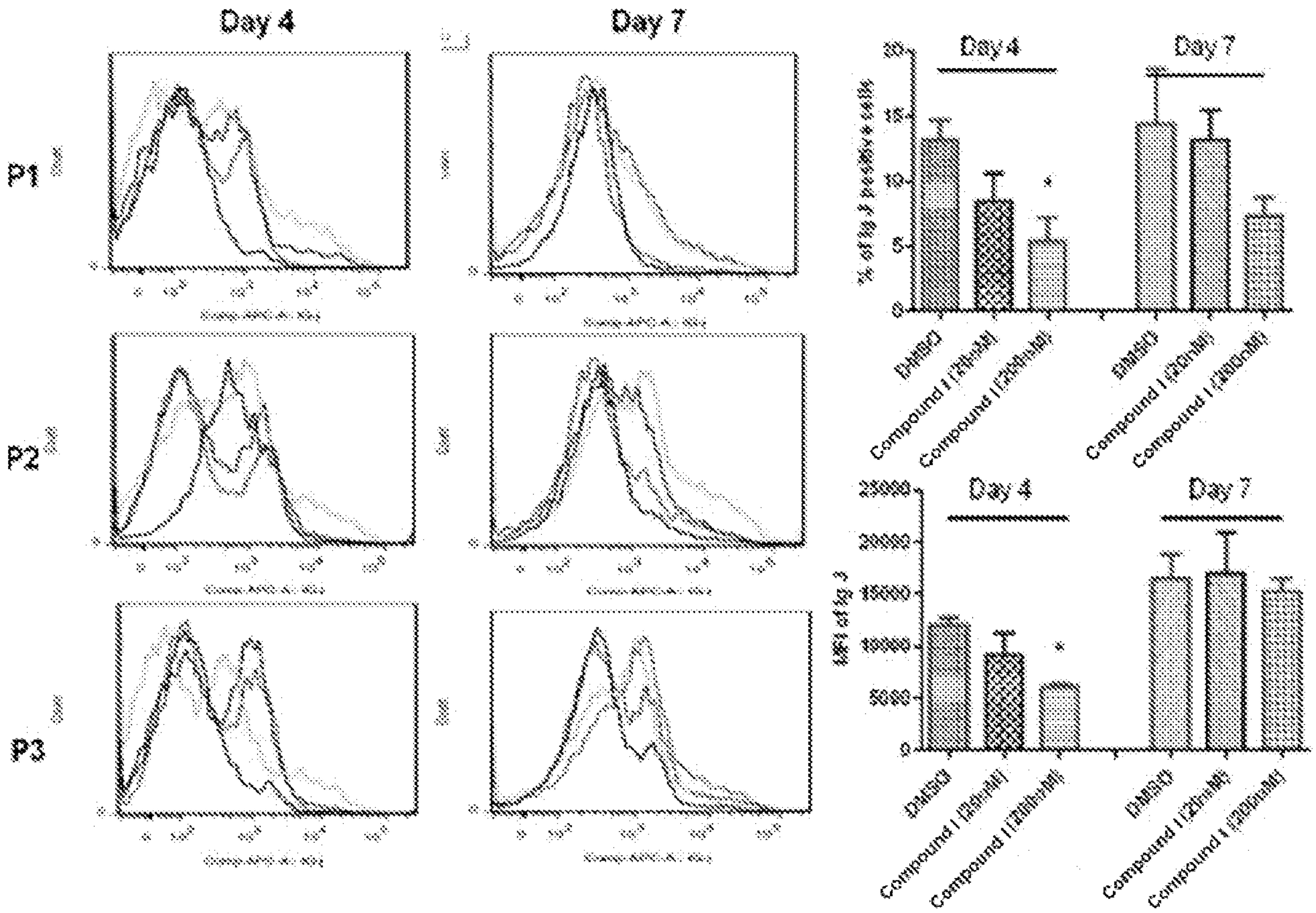

Whole population
Day 0
Day 4
Day 7
Day 4
Day 7
% of CD83+ cells
MFI of CD83
DMSO
Compound I
One-way analysis of variance
Dunnett's Multiple Comparison Test
(compared with same group DMSO control)

FIG. 20


Day 4
Day 7
P1
P2
P3
Day 4
Day 7
DMSO
Compound I (20nM)
Compound I (200nM)
Day 4
Day 7
MFI of Ig J
DMSO
Compound I (20nM)
Compound I (200nM)

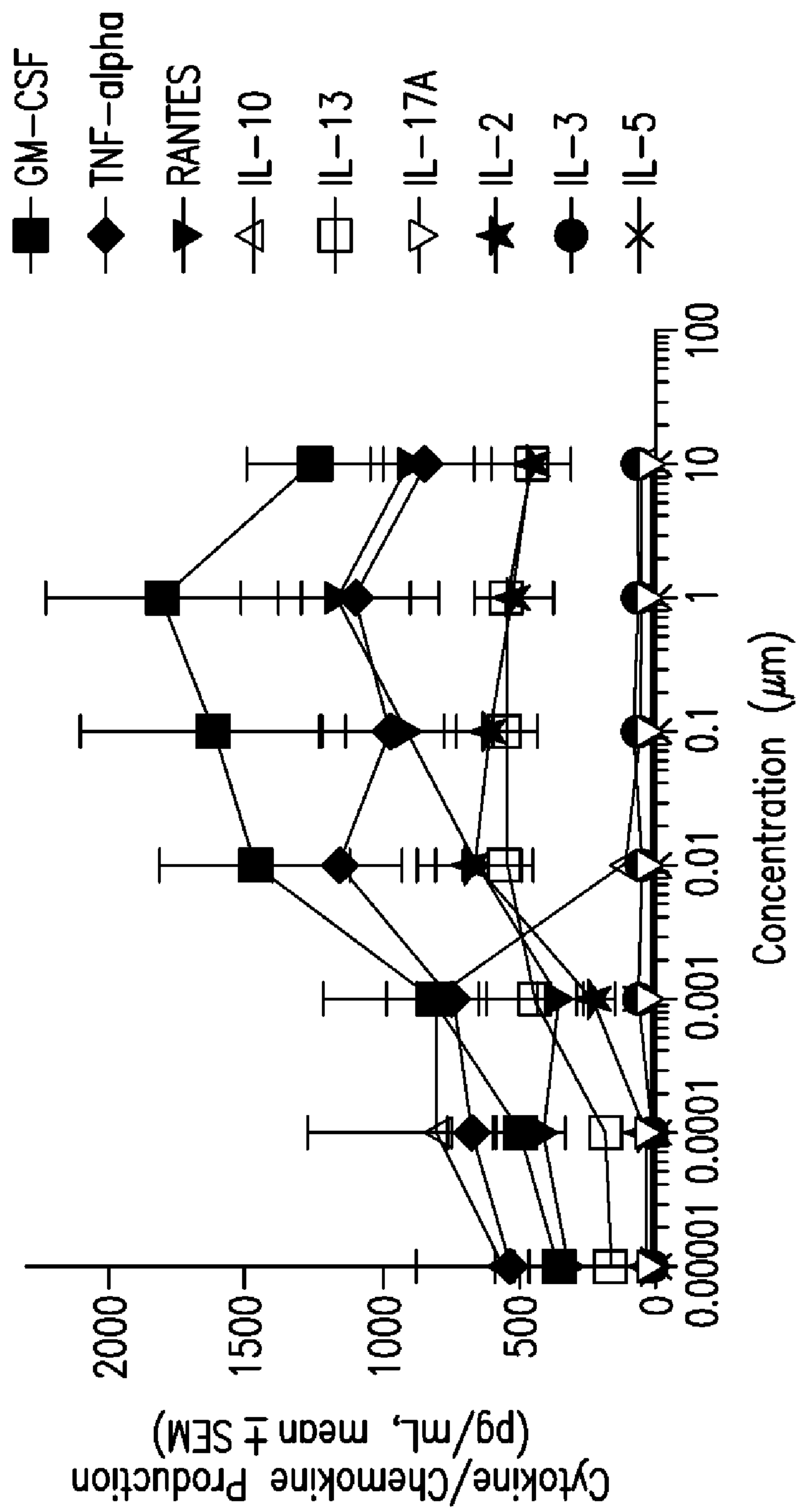

GM–CSF
TNF–alpha
RANTES
IL–10
IL–13
IL–17A
IL–2
IL–3
IL–5
Cytokine/Chemokine Production (pg/mL, mean ± SEM)
2000
1500
1000
500
0
0.00001
0.0001
0.001
0.01
0.1
1
10
100
Concentration (µm)

FIG. 21

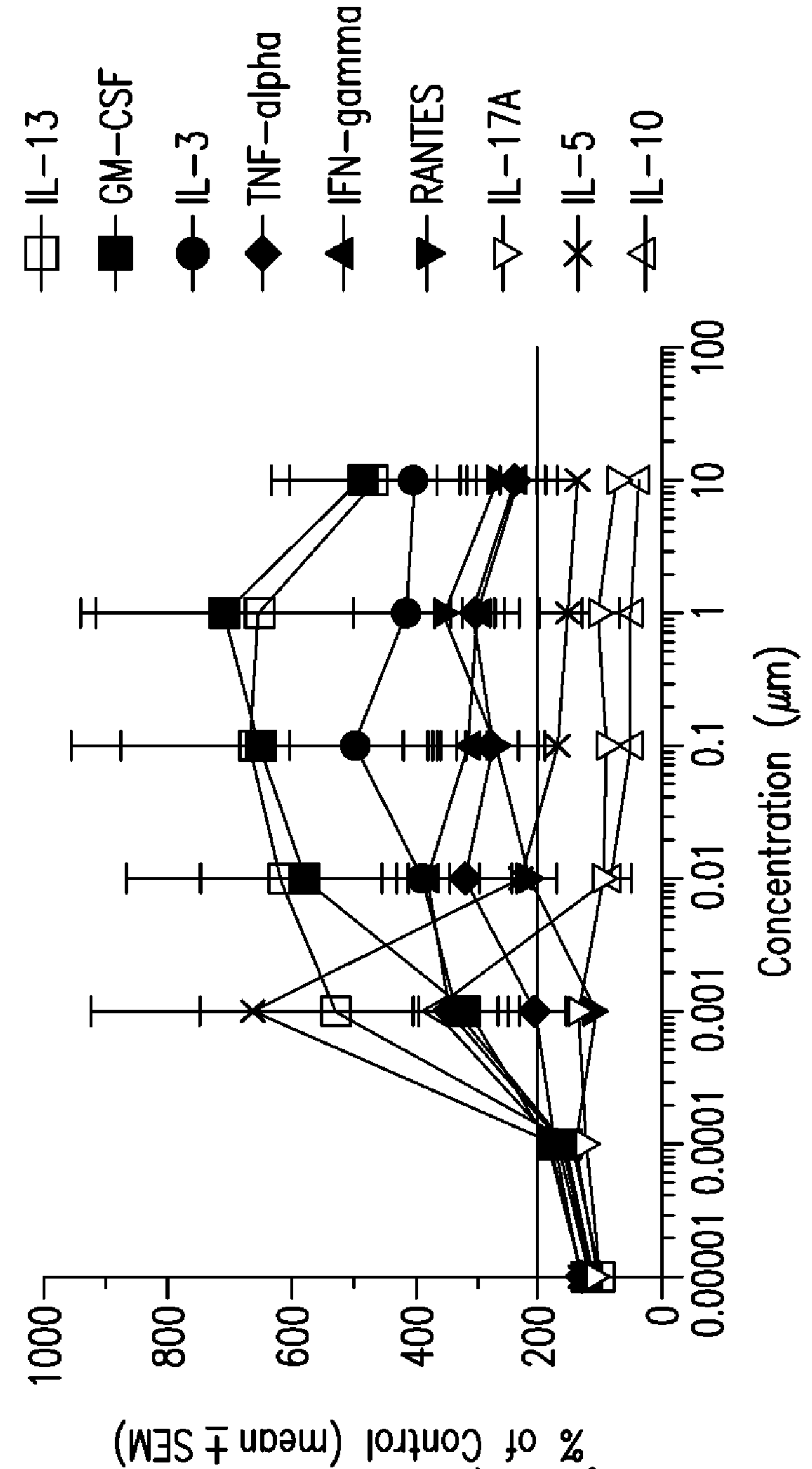

Cytokine/Chemokine Production
% of Control (mean ± SEM)
1000
800
600
400
200
0
0.00001
0.0001
0.001
0.01
0.1
1
10
100
Concentration (μm)
IL-13
GM-CSF
IL-3
TNF-alpha
IFN-gamma
RANTES
IL-17A
IL-5
IL-10

FIG. 22

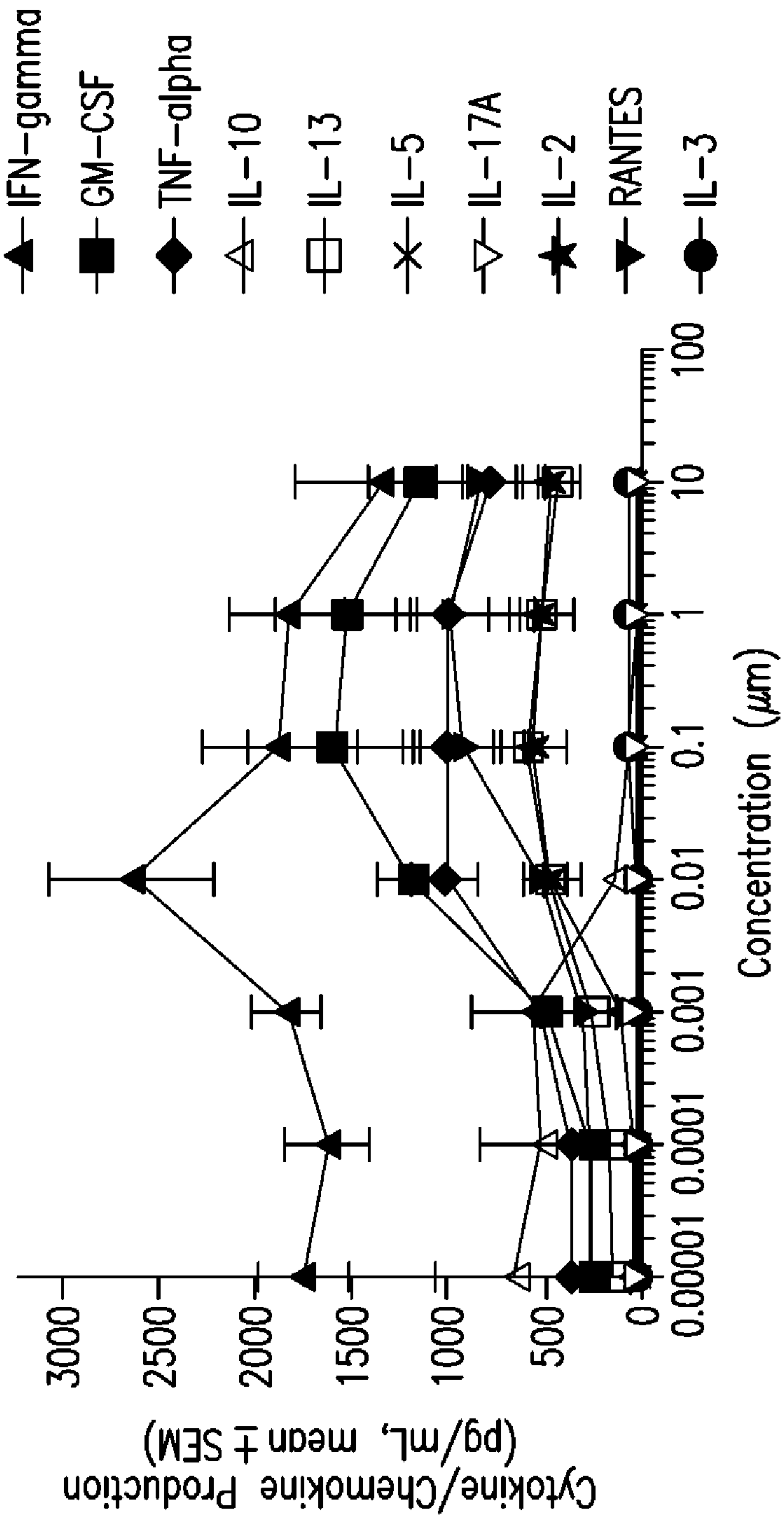

Cytokine/Chemokine Production (pg/mL, mean ± SEM)
0
500
1000
1500
2000
2500
3000
0.00001
0.0001
0.001
0.01
0.1
1
10
100
Concentration (μm)
IFN-gamma
GM-CSF
TNF-alpha
IL-10
IL-13
IL-5
IL-17A
IL-2
RANTES
IL-3

FIG. 23

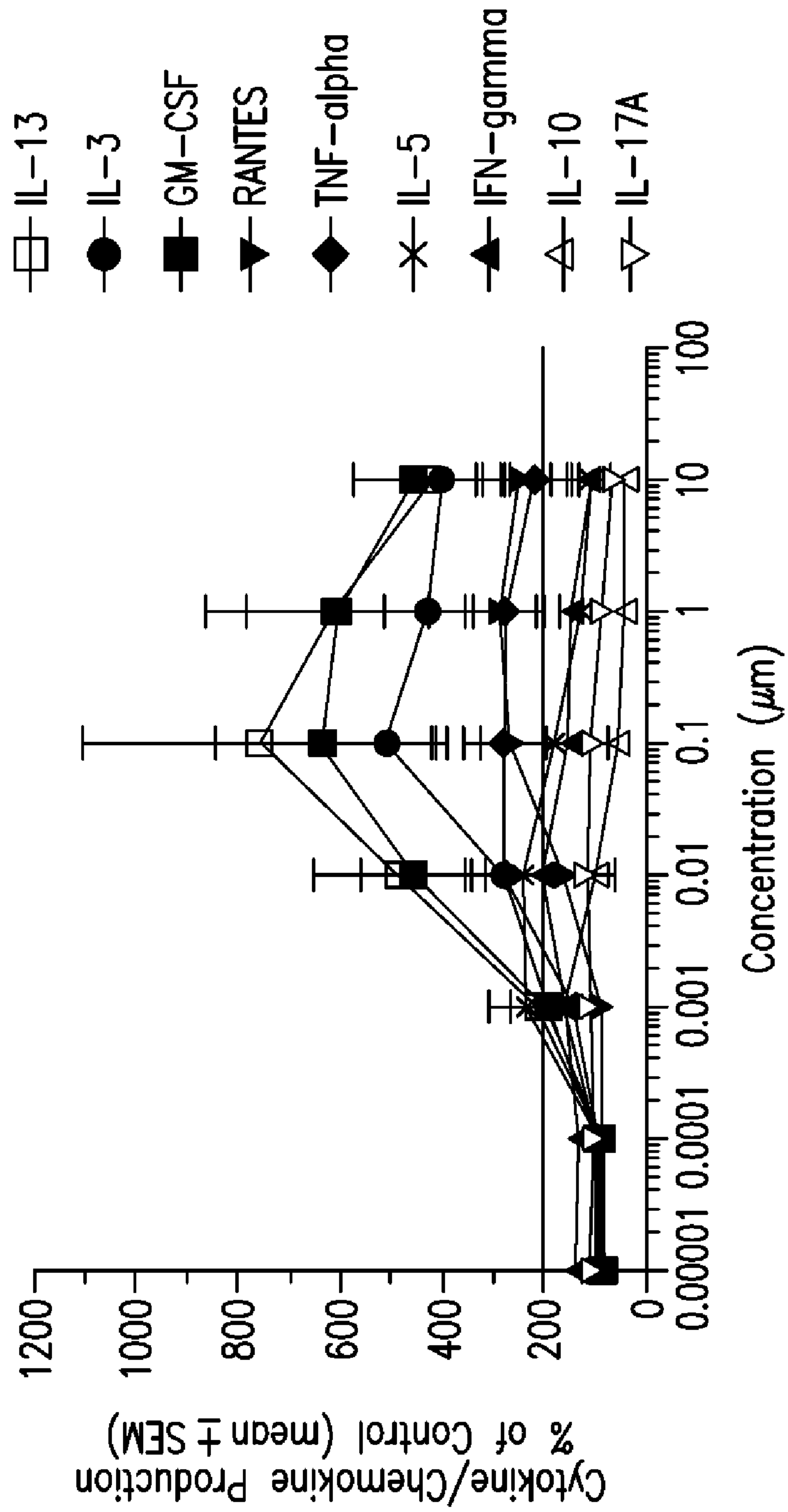

IL-13
IL-3
GM-CSF
RANTES
TNF-alpha
IL-5
IFN-gamma
IL-10
IL-17A
Cytokine/Chemokine Production % of Control (mean ± SEM)
1200
1000
800
600
400
200
0
0.00001
0.0001
0.001
0.01
0.1
1
10
100
Concentration (μm)

FIG. 24

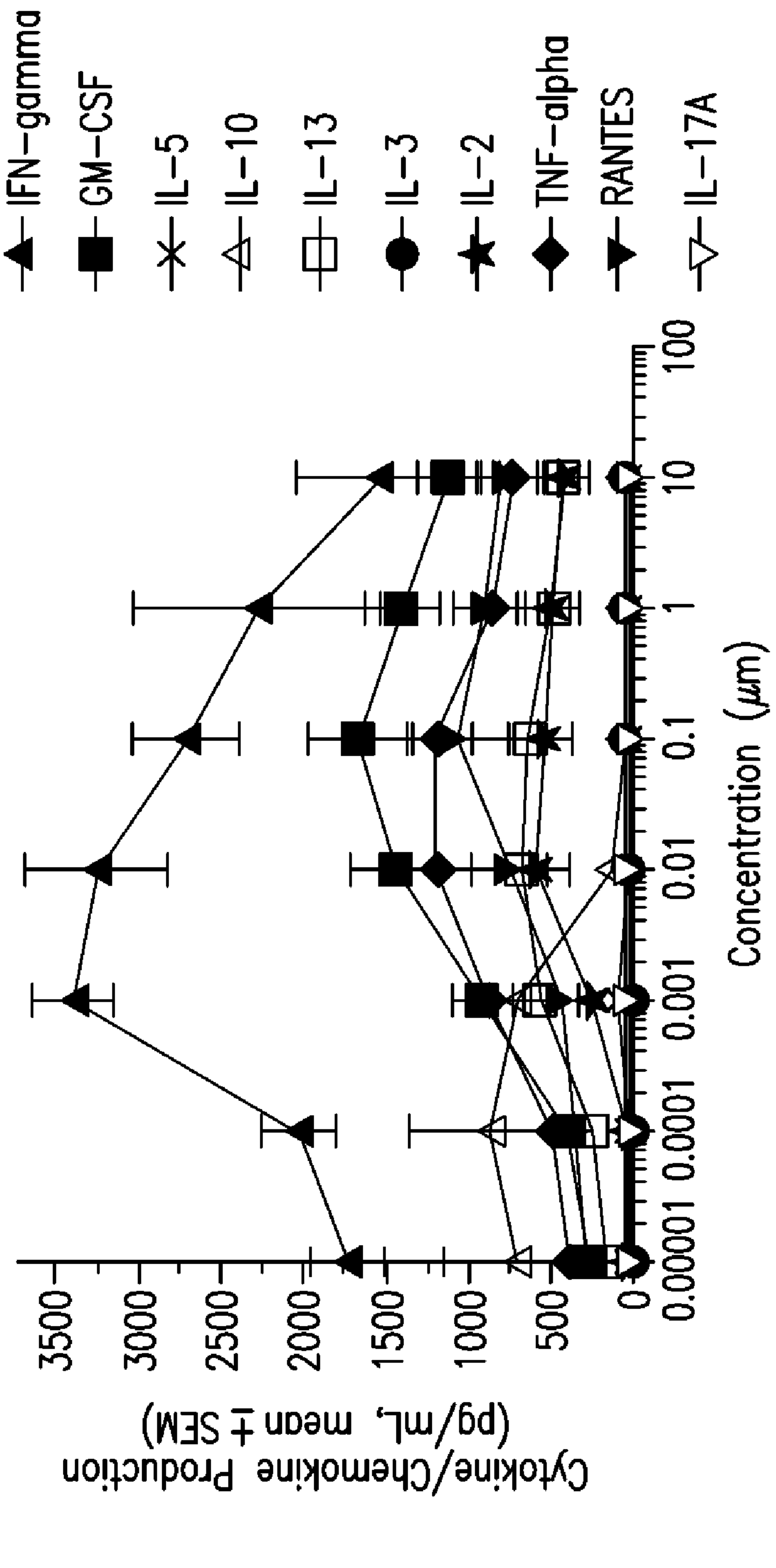

Cytokine/Chemokine Production (pg/mL, mean ± SEM)
3500
3000
2500
2000
1500
1000
500
0
0.00001
0.0001
0.001
0.01
0.1
1
10
100
Concentration (μm)
IFN-gamma
GM-CSF
IL-5
IL-10
IL-13
IL-3
IL-2
TNF-alpha
RANTES
IL-17A

FIG. 25

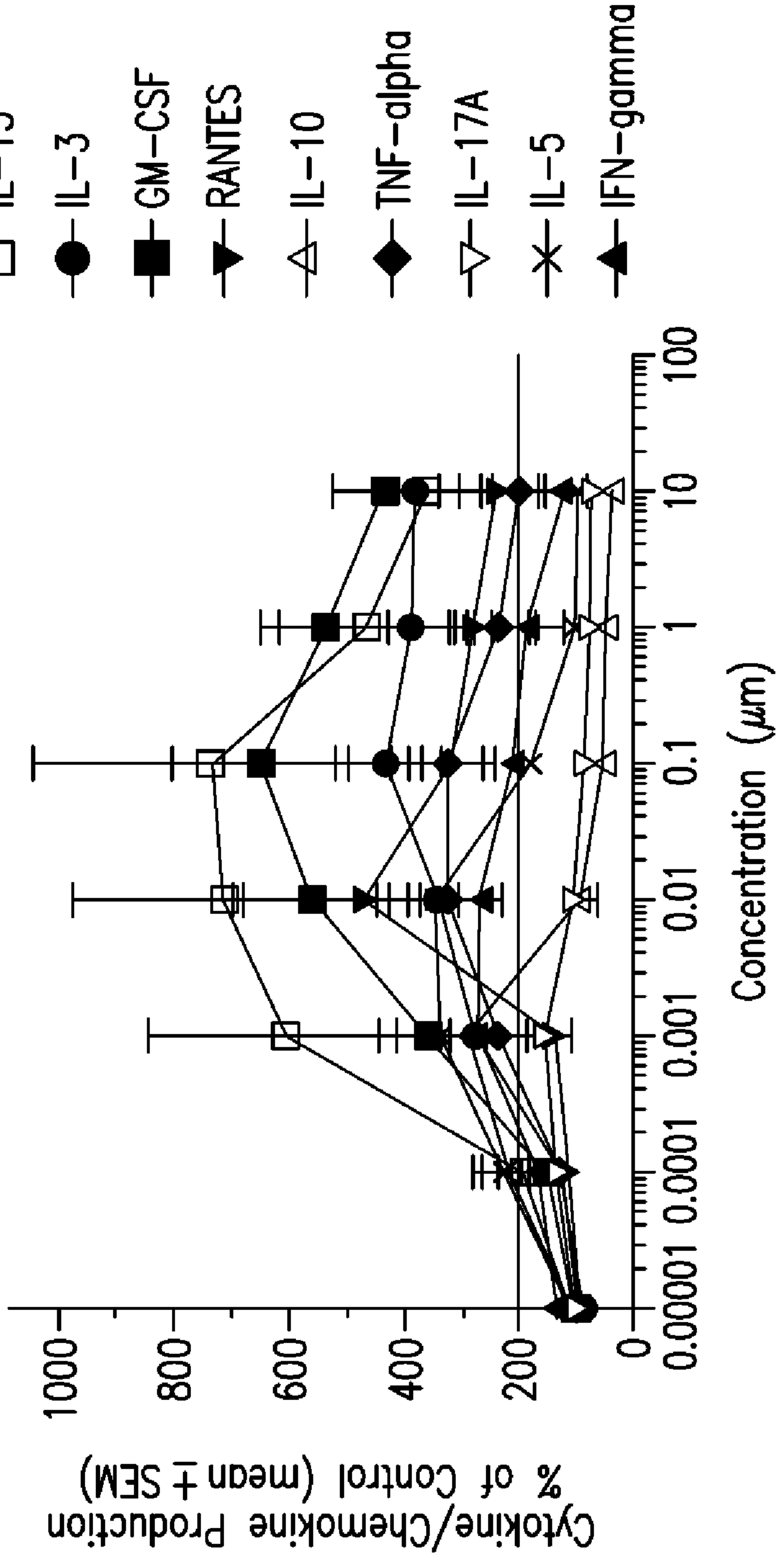

Cytokine/Chemokine Production
% of Control (mean ± SEM)
1000
800
600
400
200
0
0.00001
0.0001
0.001
0.01
0.1
1
10
100
Concentration (μm)
IL-13
IL-3
GM-CSF
RANTES
IL-10
TNF-alpha
IL-17A
IL-5
IFN-gamma

FIG. 26

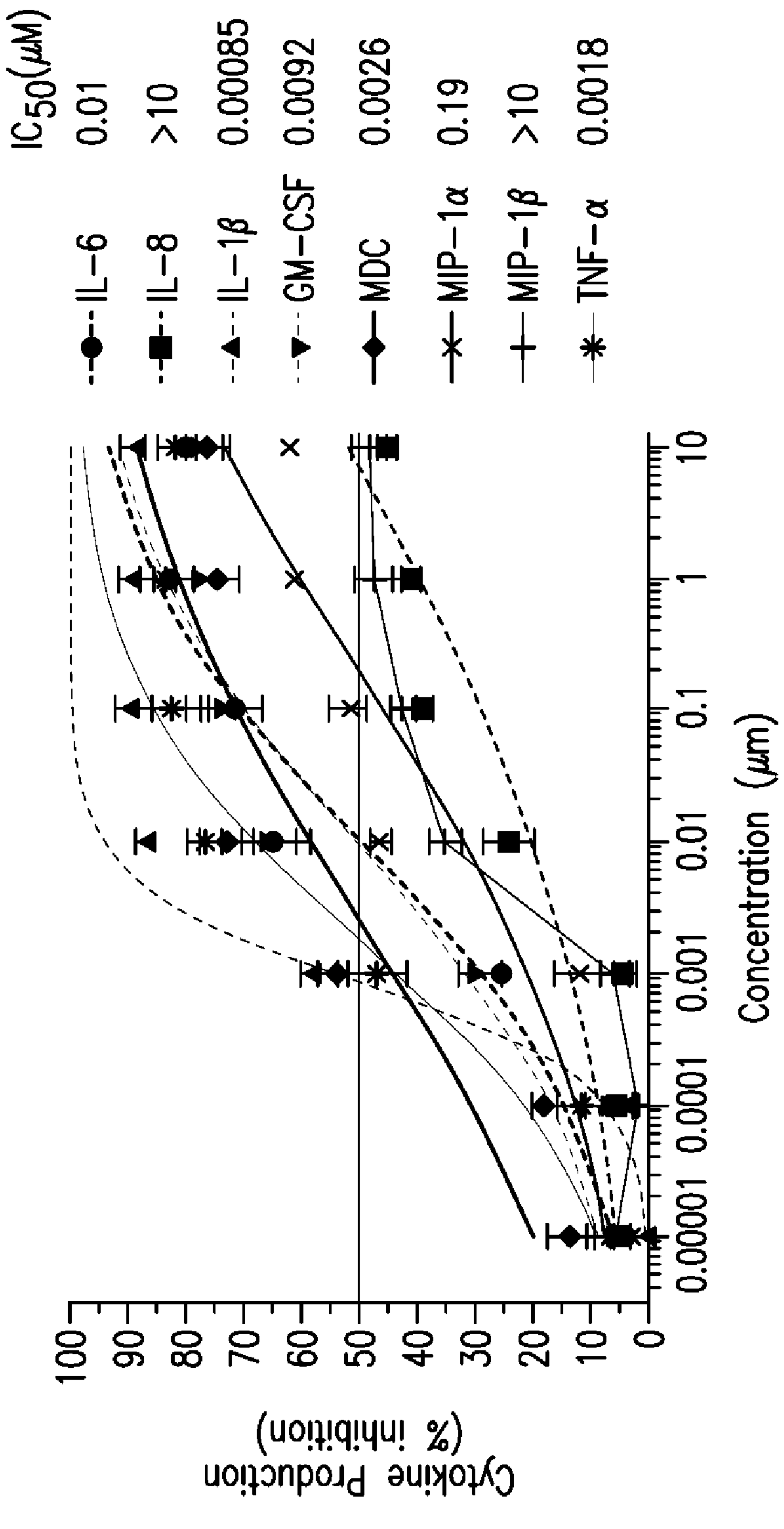

Cytokine Production (% inhibition)
100
90
80
70
60
50
40
30
20
10
0
0.00001
0.0001
0.001
0.01
0.1
1
10
Concentration (μm)
IC50(μM)
IL-6 0.01
IL-8 >10
IL-1β 0.00085
GM-CSF 0.0092
MDC 0.0026
MIP-1α 0.19
MIP-1β >10
TNF-α 0.0018

FIG. 27

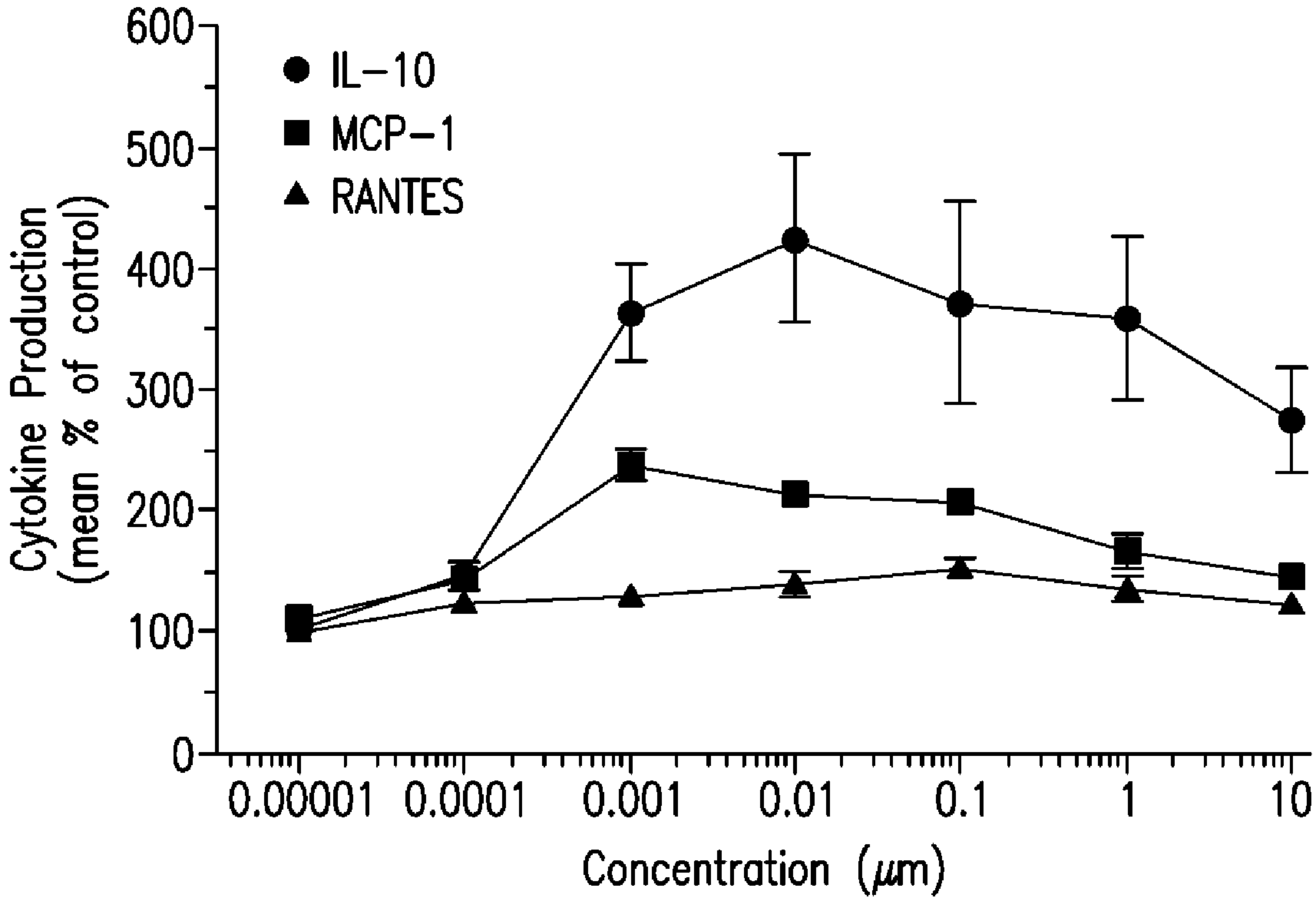

600
500
400
300
200
100
0
IL-10
MCP-1
RANTES
Cytokine Production
(mean % of control)
0.00001
0.0001
0.001
0.01
0.1
1
10
Concentration (μm)

FIG. 28

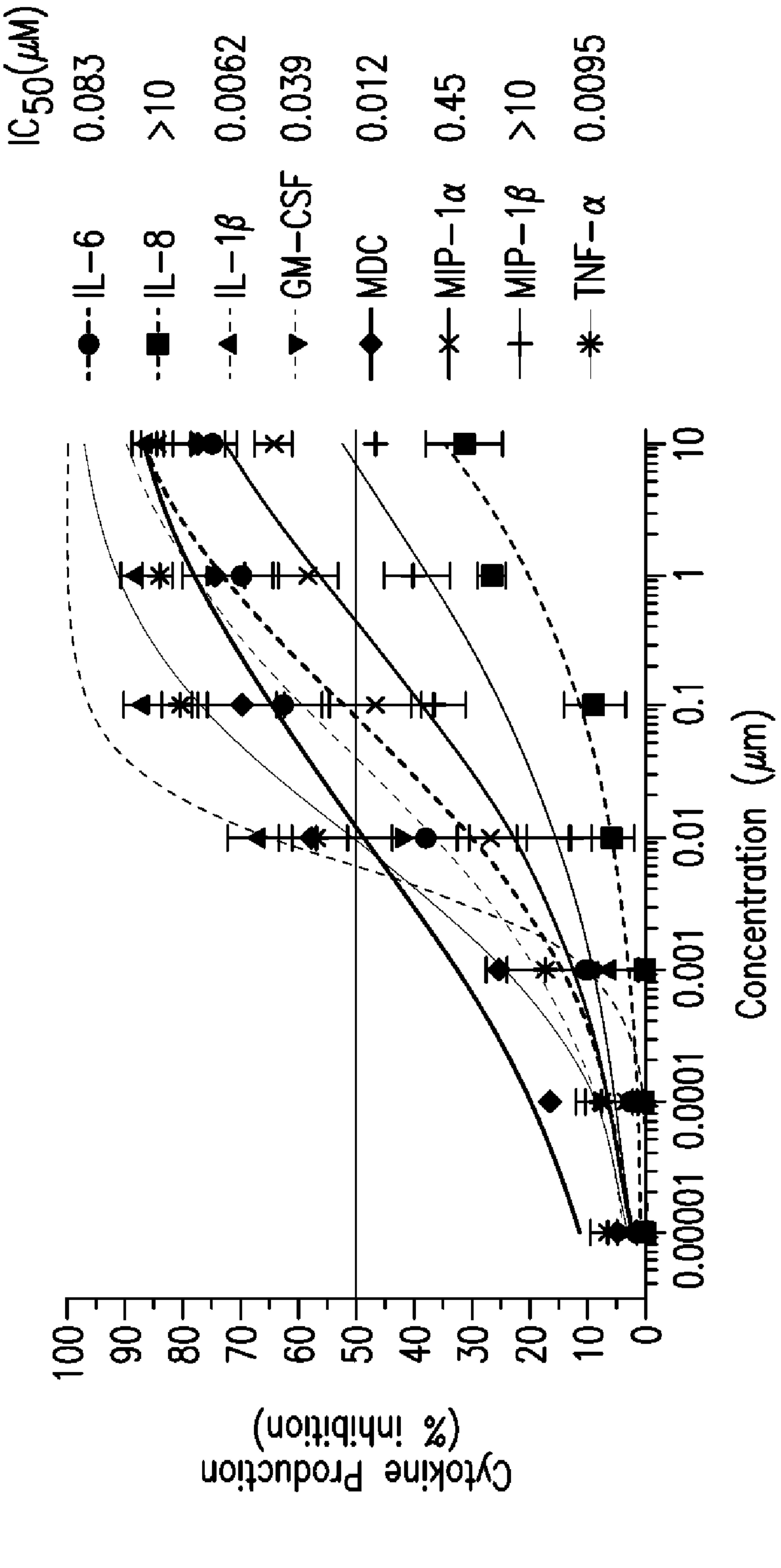

Cytokine Production (% inhibition)
100
90
80
70
60
50
40
30
20
10
0
0.00001
0.0001
0.001
0.01
0.1
1
10
Concentration (μm)
IC_{50}(μM)
IL-6 0.083
IL-8 >10
IL-1β 0.0062
GM-CSF 0.039
MDC 0.012
MIP-1α 0.45
MIP-1β >10
TNF-α 0.0095

FIG. 29

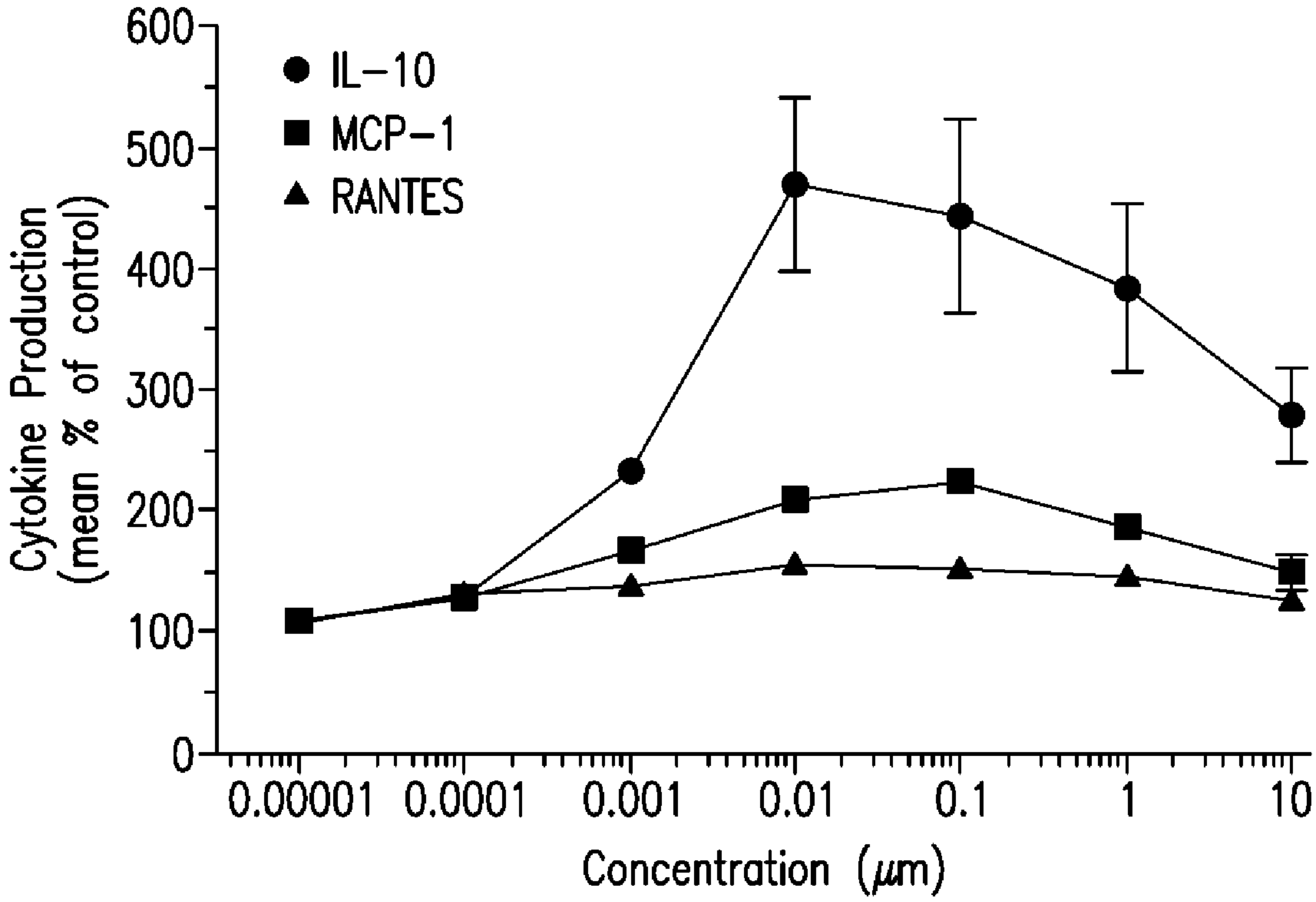

600
500
400
300
200
100
0
IL-10
MCP-1
RANTES
Cytokine Production
(mean % of control)
0.00001
0.0001
0.001
0.01
0.1
1
10
Concentration (μm)

FIG. 30

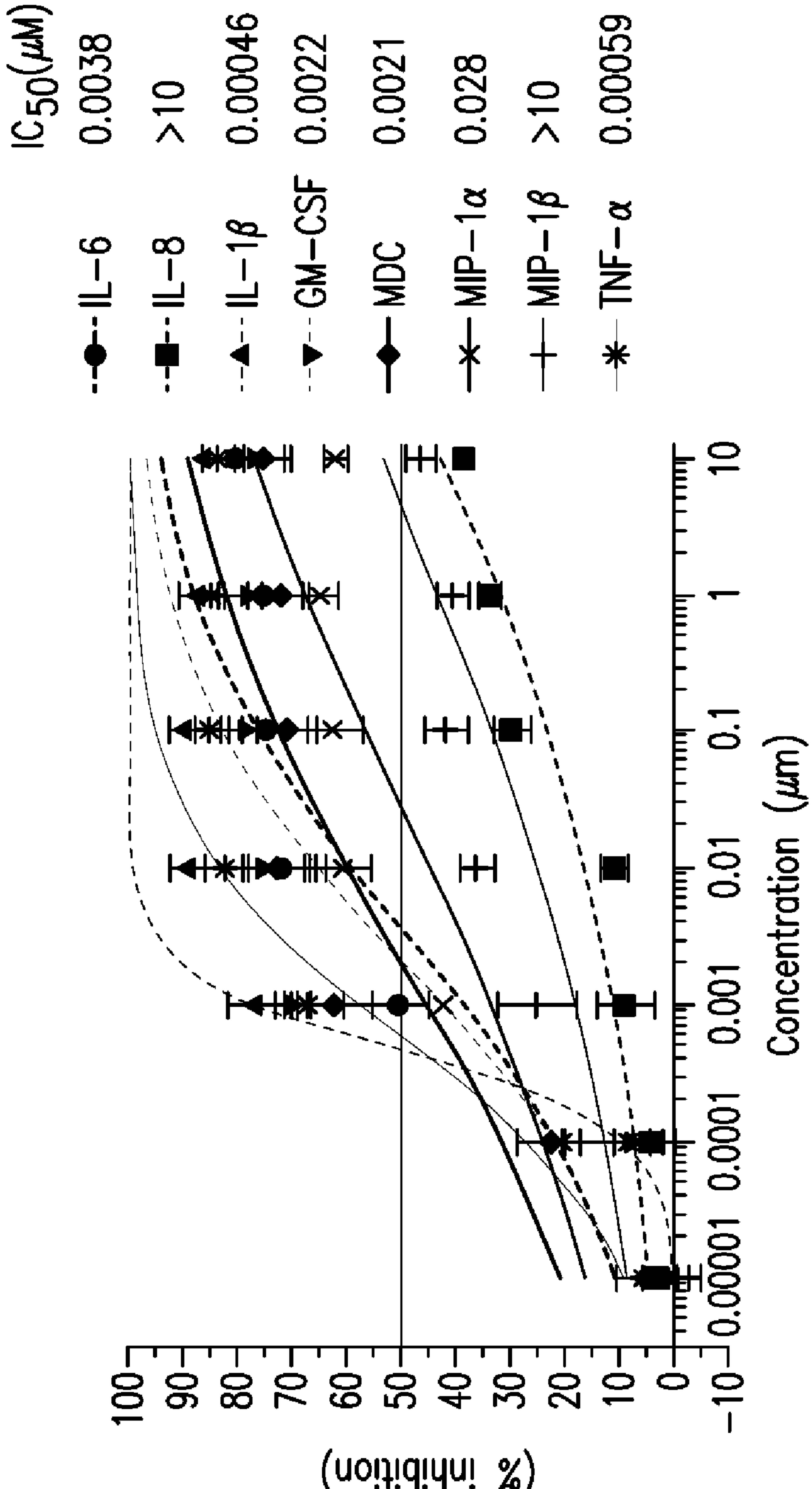

Cytokine Production (% inhibition)
100
90
80
70
60
50
40
30
20
10
0
−10
0.00001
0.0001
0.001
0.01
0.1
1
10
Concentration (μm)
IC$_{50}$(μM)
IL−6 0.0038
IL−8 >10
IL−1β 0.00046
GM−CSF 0.0022
MDC 0.0021
MIP−1α 0.028
MIP−1β >10
TNF−α 0.00059

FIG. 31

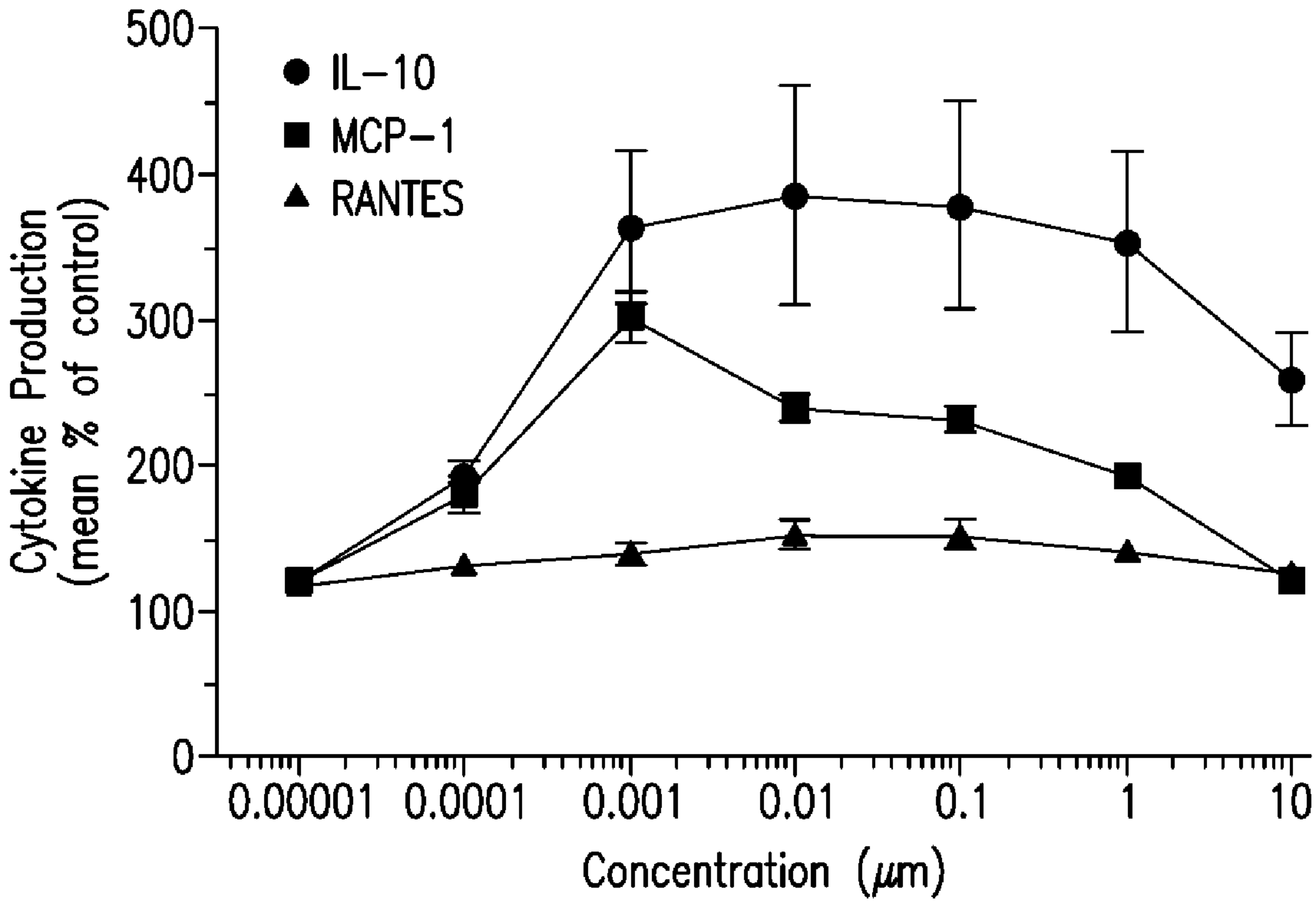

500
400
300
200
100
0
Cytokine Production (mean % of control)
IL-10
MCP-1
RANTES
0.00001
0.0001
0.001
0.01
0.1
1
10
Concentration (μm)

FIG. 32

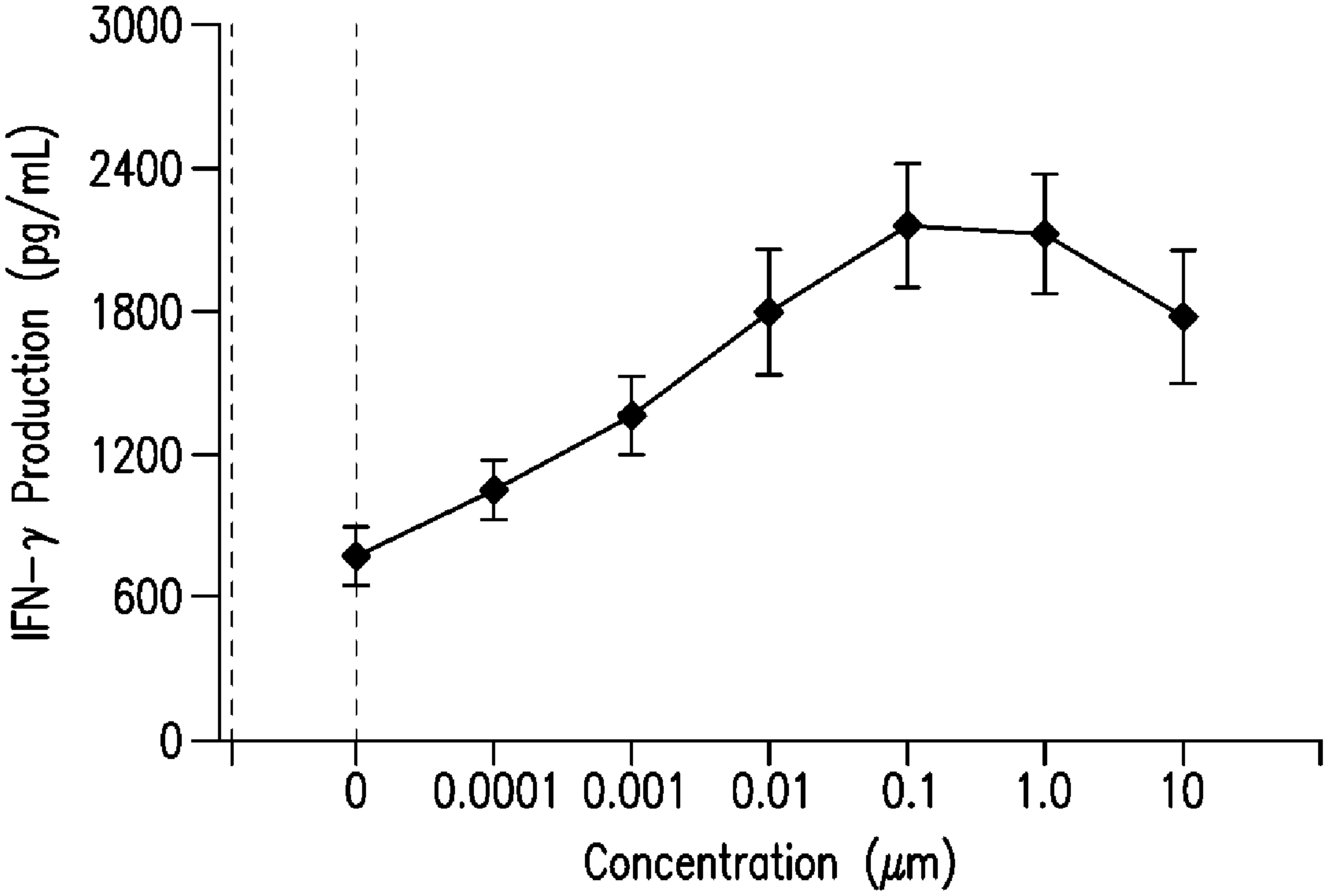

3000
2400
1800
1200
600
0
IFN-γ Production (pg/mL)
0
0.0001
0.001
0.01
0.1
1.0
10
Concentration (μm)

FIG. 33

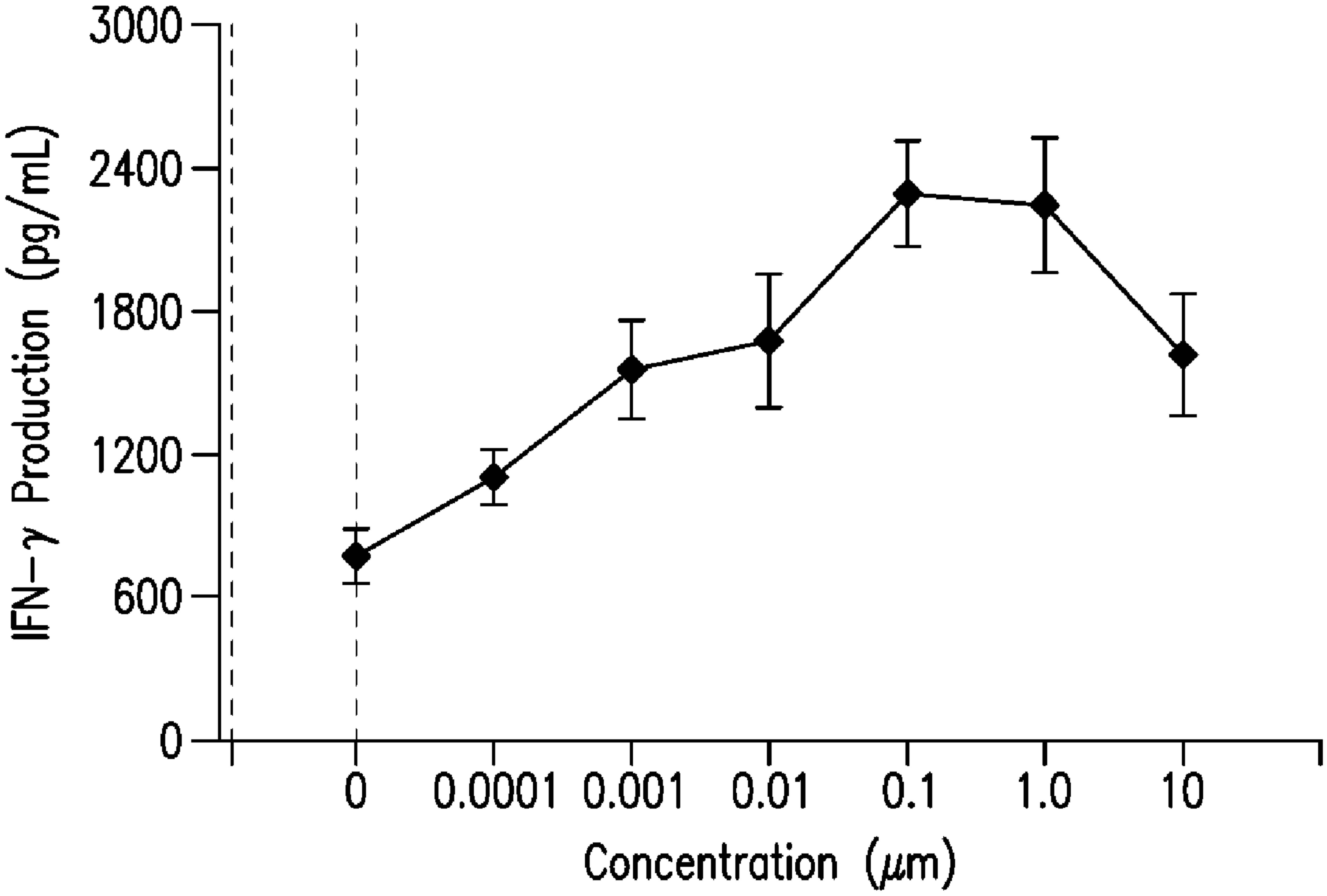

IFN-γ Production (pg/mL)
3000
2400
1800
1200
600
0
0
0.0001
0.001
0.01
0.1
1.0
10
Concentration (μm)

FIG. 34

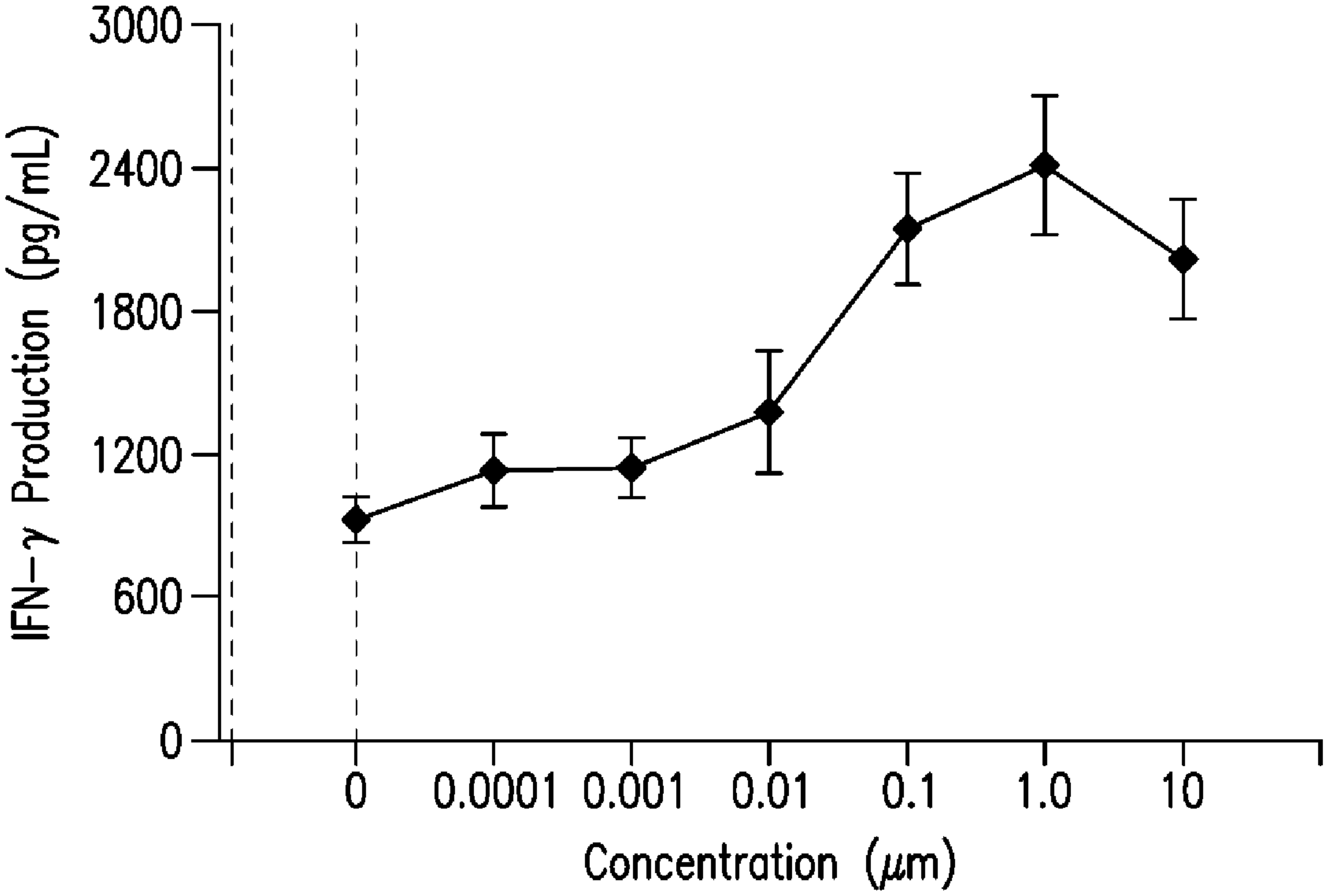

3000
2400
1800
1200
600
0
IFN-γ Production (pg/mL)
0
0.0001
0.001
0.01
0.1
1.0
10
Concentration (μm)

FIG. 35

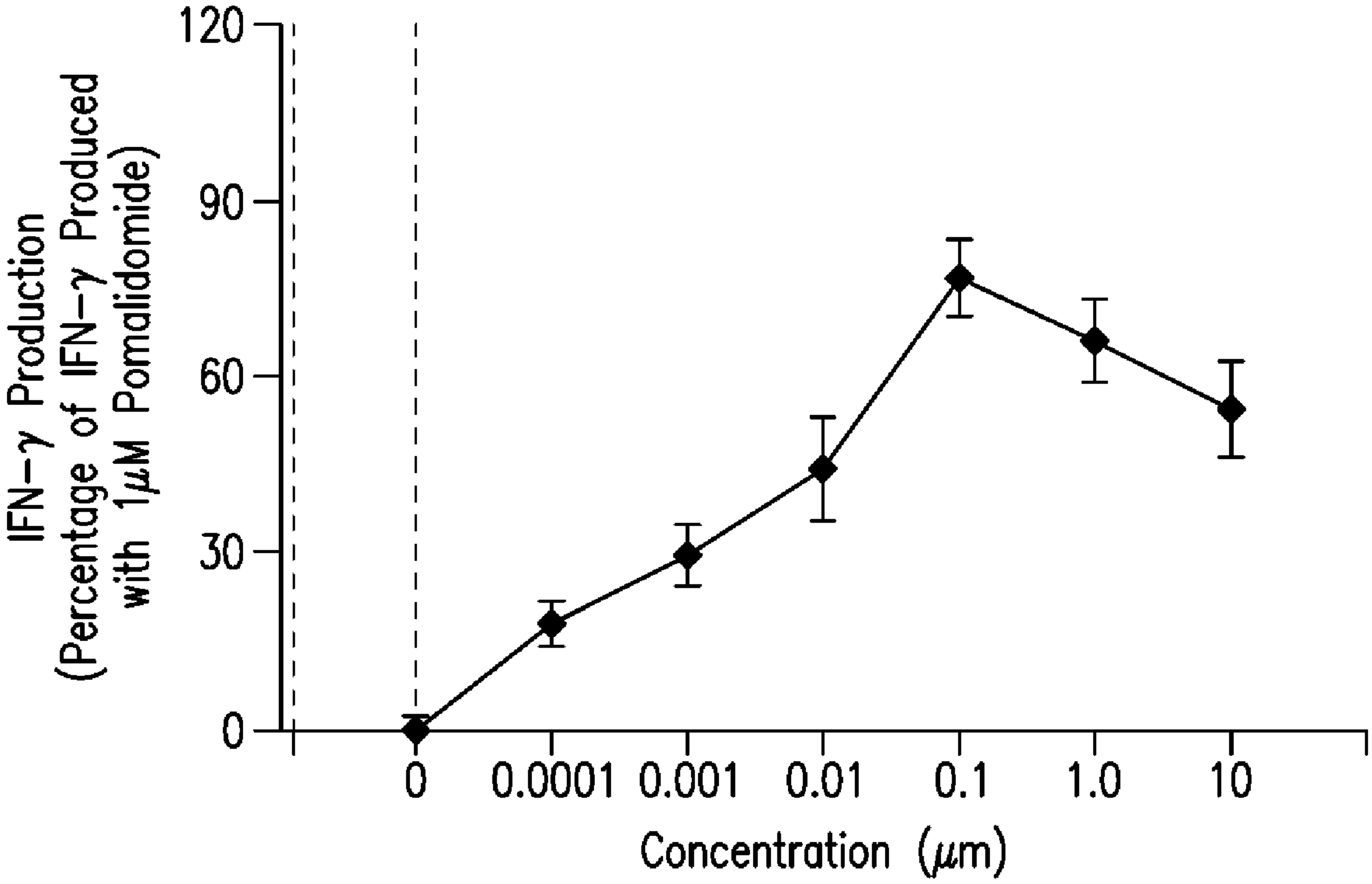

IFN-γ Production
(Percentage of IFN-γ Produced
with 1μM Pomalidomide)
120
90
60
30
0
0
0.0001
0.001
0.01
0.1
1.0
10
Concentration (μm)

FIG. 36

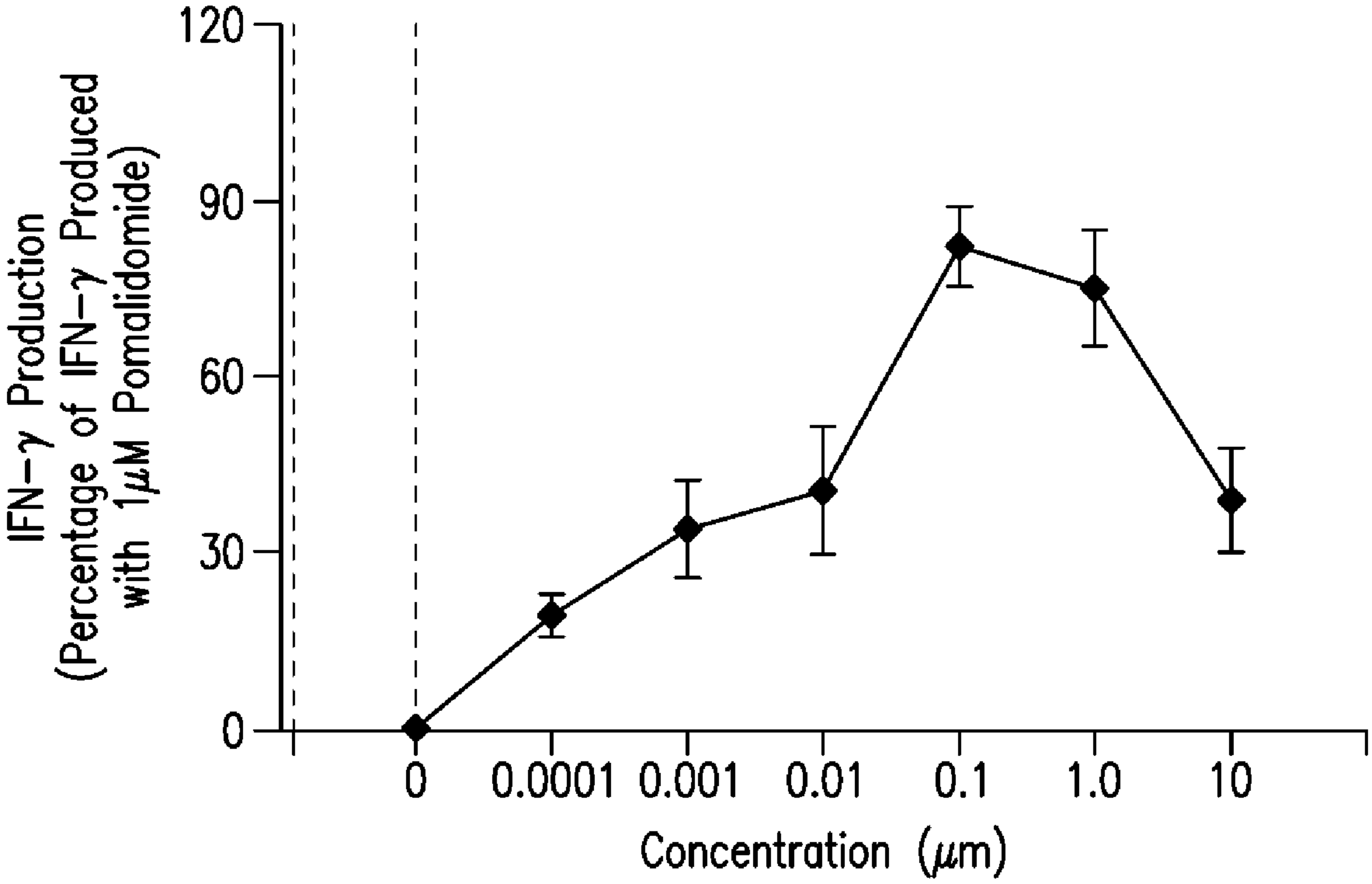

IFN-γ Production
(Percentage of IFN-γ Produced
with 1μM Pomalidomide)
120
90
60
30
0
0
0.0001
0.001
0.01
0.1
1.0
10
Concentration (μm)

FIG. 37

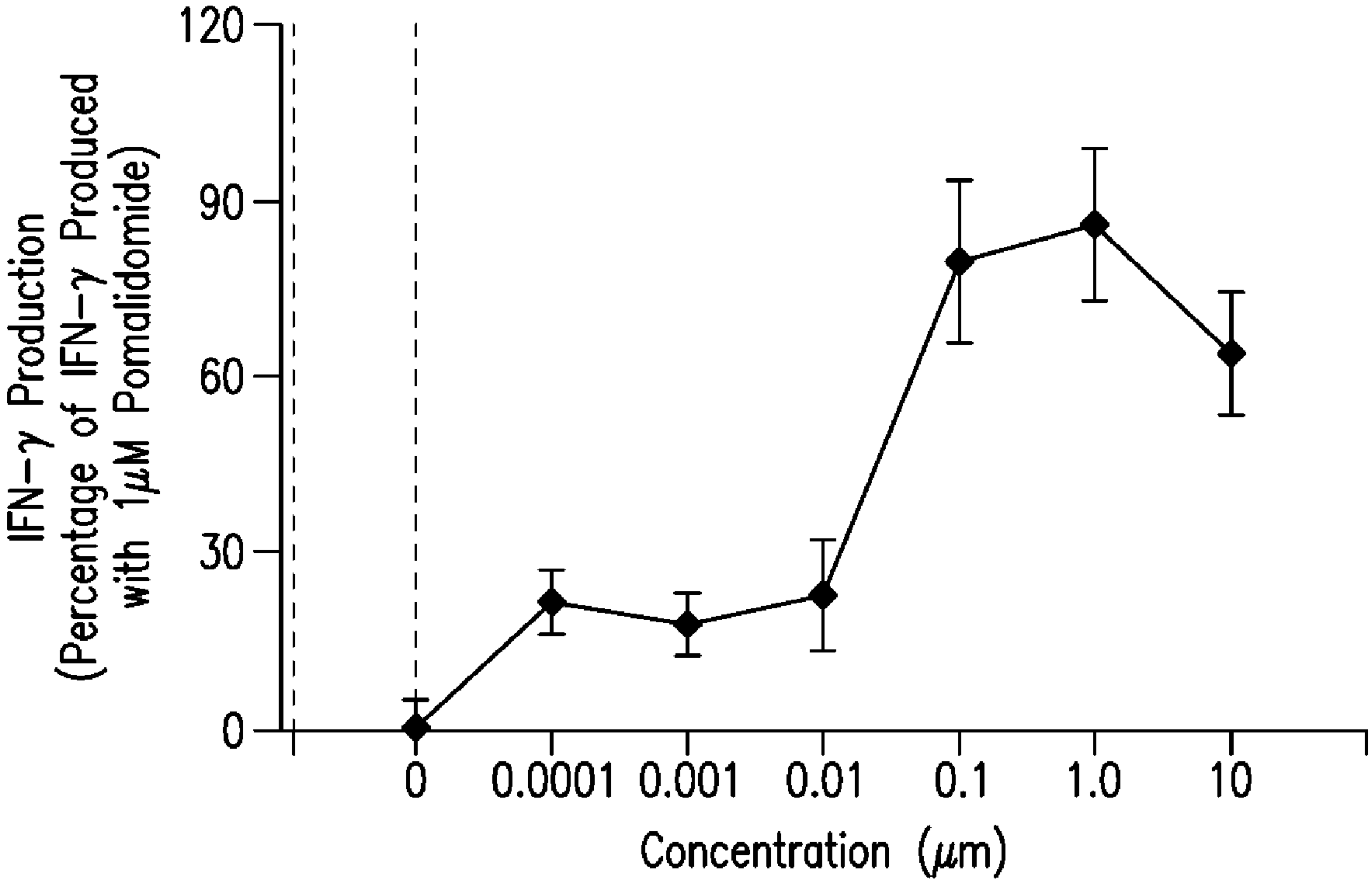

120
90
60
30
0
IFN-γ Production
(Percentage of IFN-γ Produced
with 1μM Pomalidomide)
0
0.0001
0.001
0.01
0.1
1.0
10
Concentration (μm)

FIG. 38

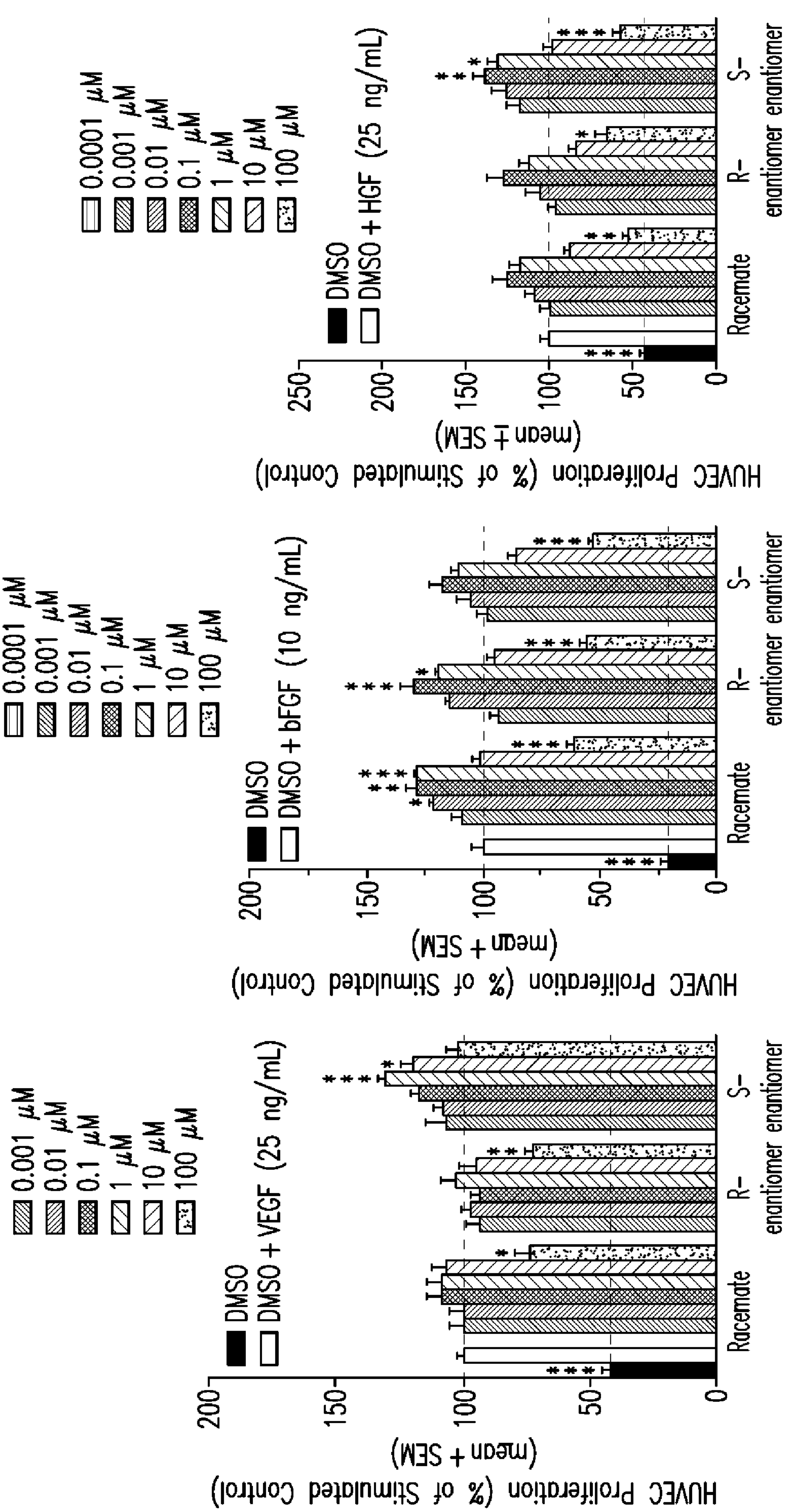

HUVEC Proliferation (% of Stimulated Control) (mean + SEM)
DMSO
DMSO + VEGF (25 ng/mL)
0.001 μM
0.01 μM
0.1 μM
1 μM
10 μM
100 μM
Racemate
R– enantiomer
S– enantiomer
DMSO + bFGF (10 ng/mL)
0.0001 μM
DMSO + HGF (25 ng/mL)
HUVEC Proliferation (% of Stimulated Control) (mean ∓ SEM)
0
50
100
150
200
250

FIG. 39

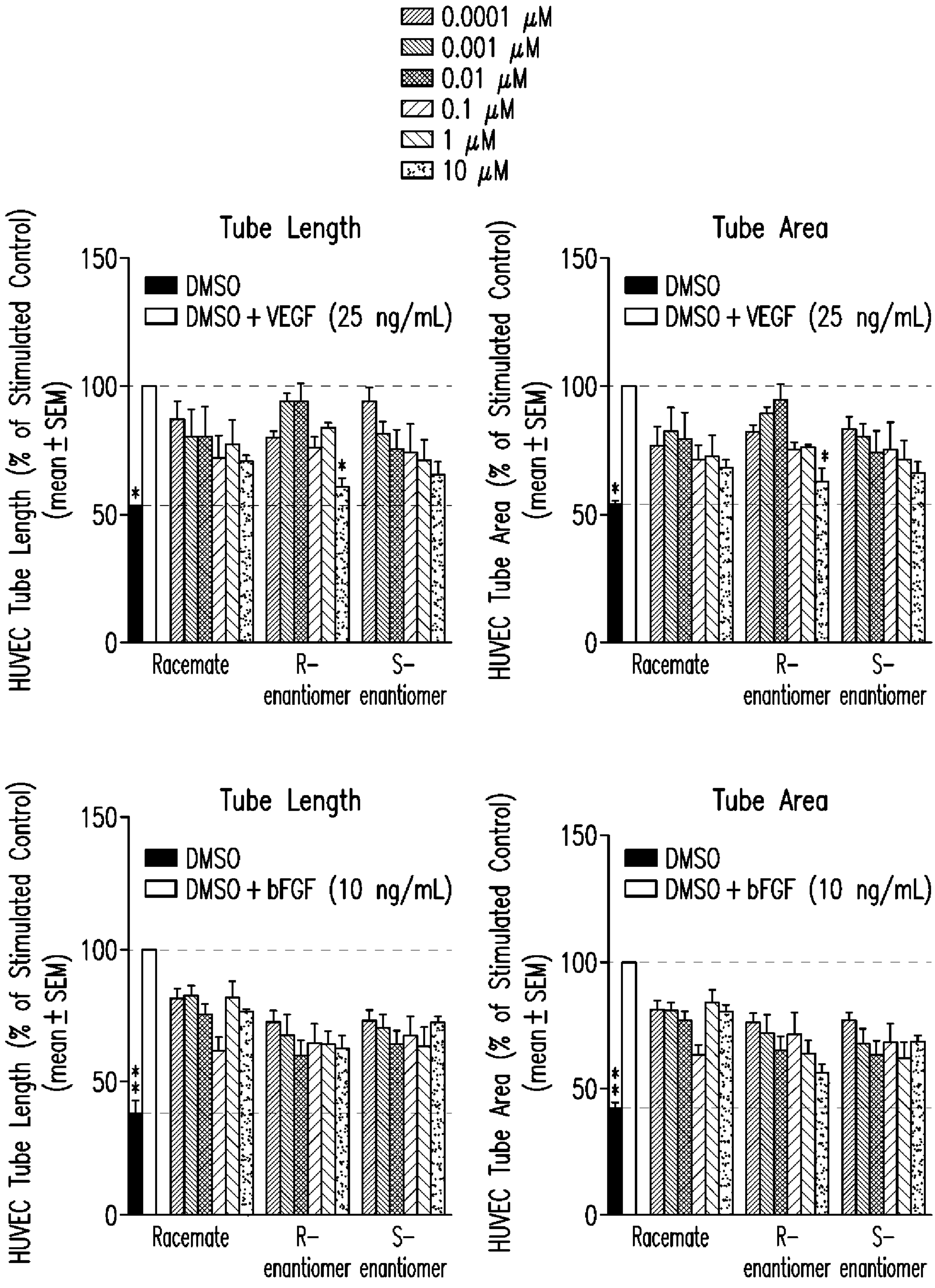

0.0001 μM
0.001 μM
0.01 μM
0.1 μM
1 μM
10 μM
Tube Length
HUVEC Tube Length (% of Stimulated Control) (mean ± SEM)
DMSO
DMSO + VEGF (25 ng/mL)
150
100
50
0
Racemate
R-enantiomer
S-enantiomer
Tube Area
HUVEC Tube Area (% of Stimulated Control) (mean ± SEM)
DMSO
DMSO + VEGF (25 ng/mL)
Tube Length
DMSO
DMSO + bFGF (10 ng/mL)
Tube Area
DMSO
DMSO + bFGF (10 ng/mL)

FIG. 40

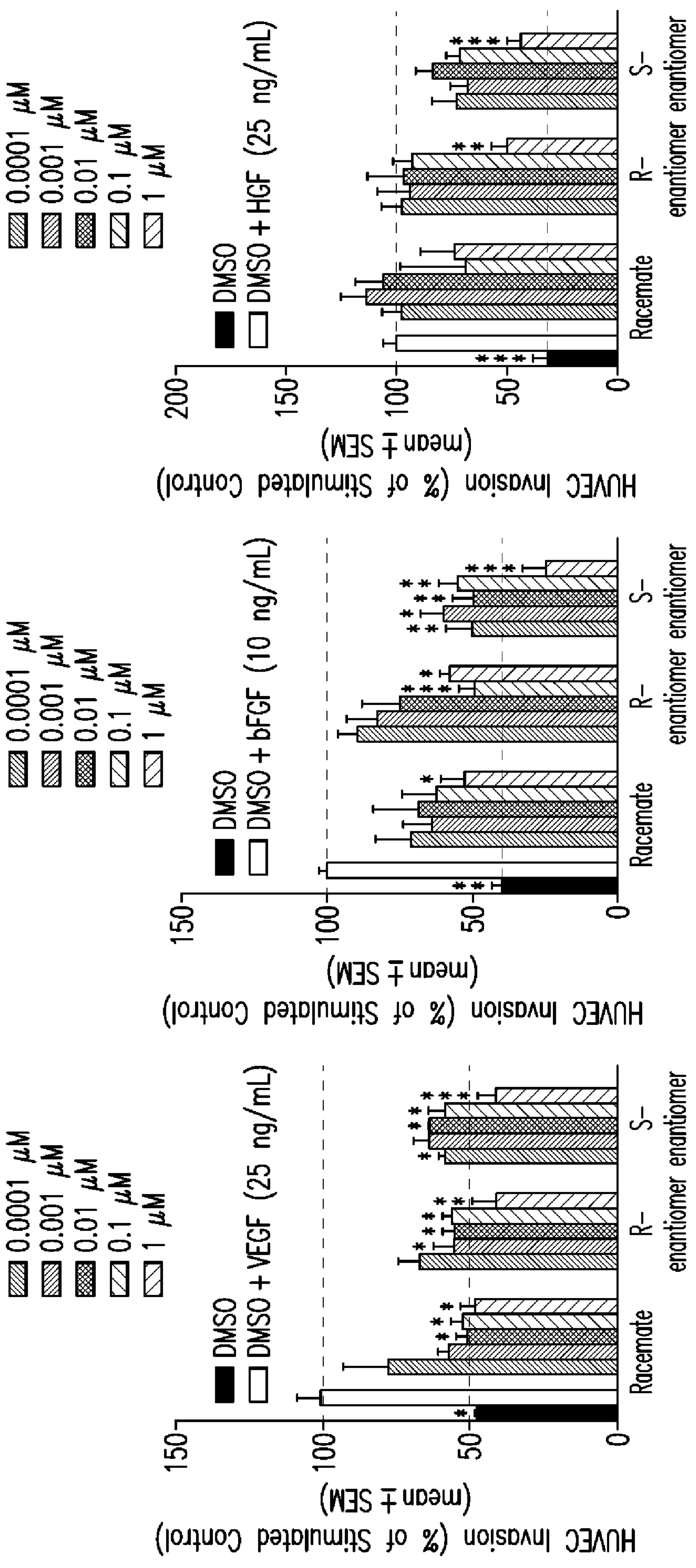

DMSO
DMSO + VEGF (25 ng/mL)
DMSO + bFGF (10 ng/mL)
DMSO + HGF (25 ng/mL)
0.0001 μM
0.001 μM
0.01 μM
0.1 μM
1 μM
HUVEC Invasion (% of Stimulated Control)
(mean ± SEM)
Racemate
R-enantiomer
S-enantiomer

FIG. 41

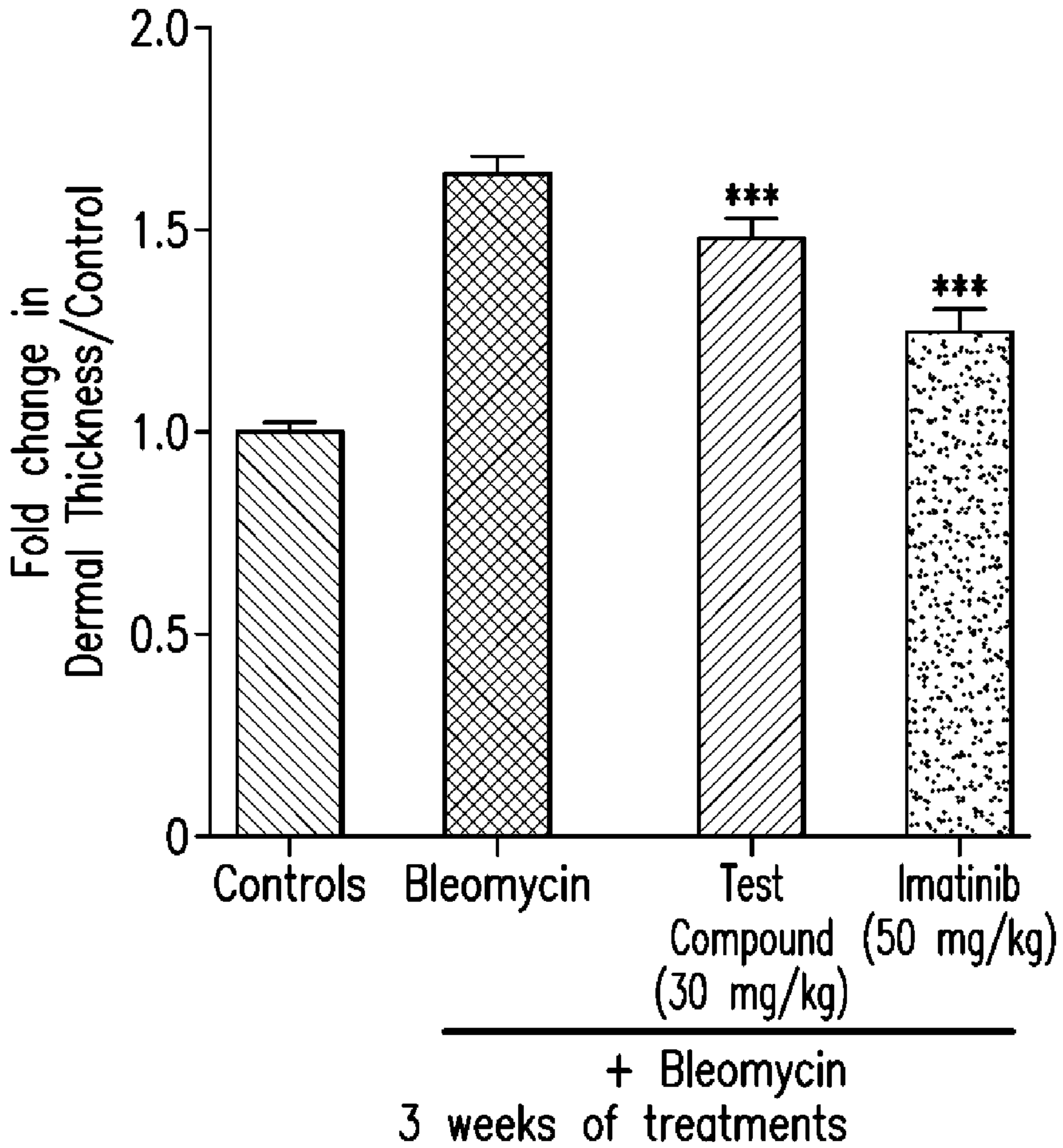
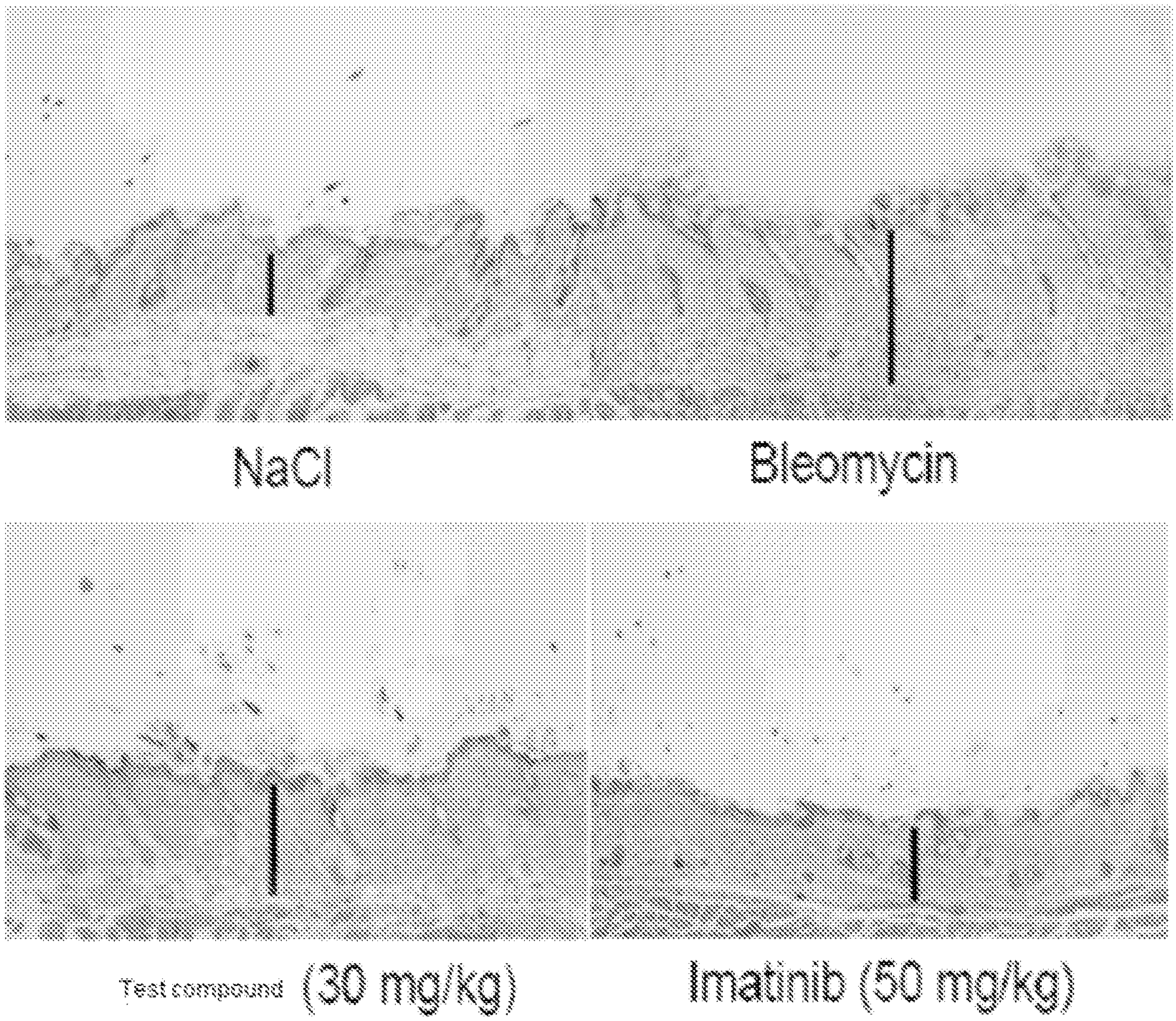

Fold change in Dermal Thickness/Control
2.0
1.5
1.0
0.5
0
***
***
Controls
Bleomycin
Test Compound (30 mg/kg)
Imatinib (50 mg/kg)
+ Bleomycin
3 weeks of treatments

FIG. 42

FIG. 43



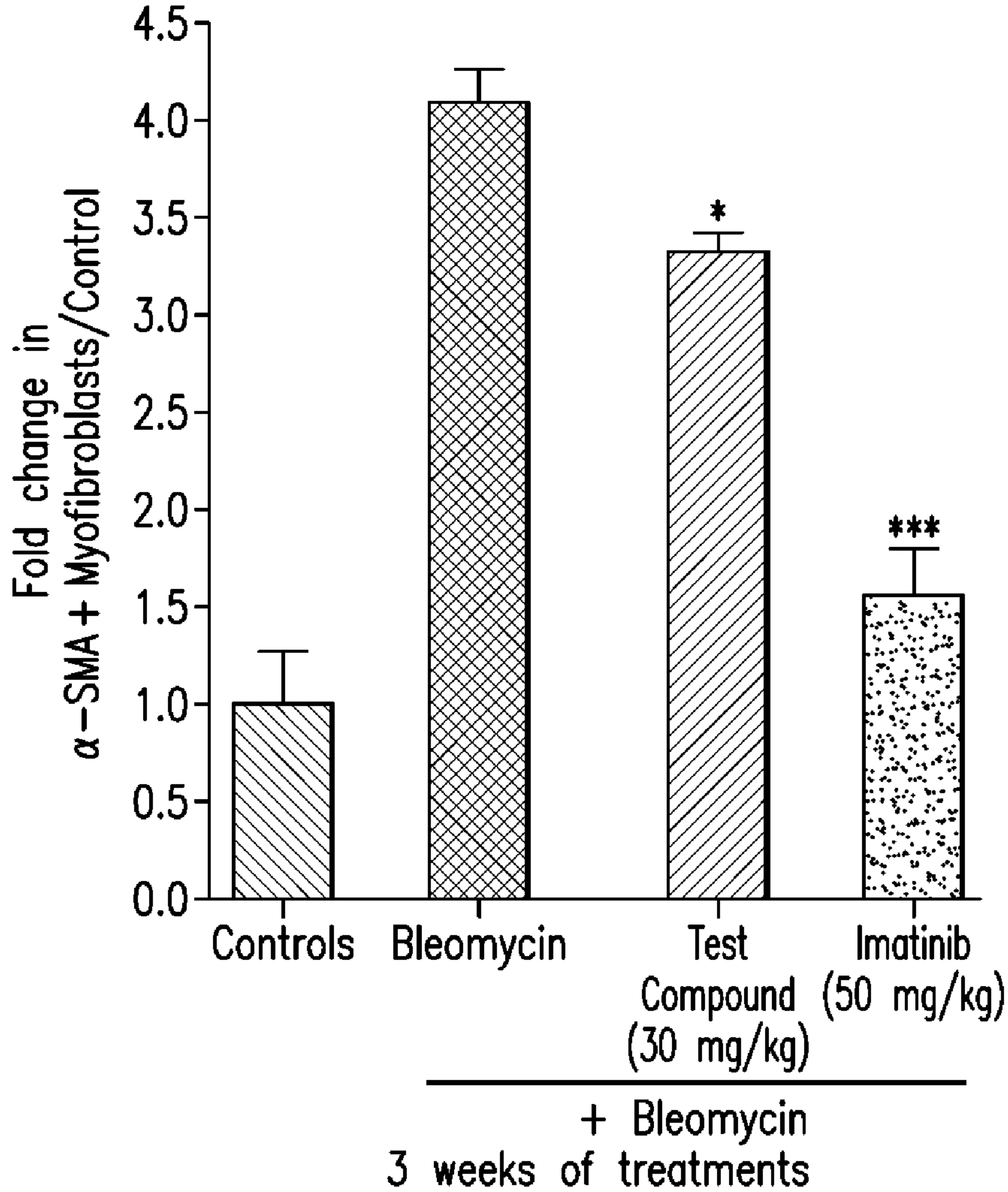

4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Fold change in
α−SMA + Myofibroblasts/Control
*
***
Controls
Bleomycin
Test Compound (30 mg/kg)
Imatinib (50 mg/kg)
+ Bleomycin
3 weeks of treatments

FIG. 44

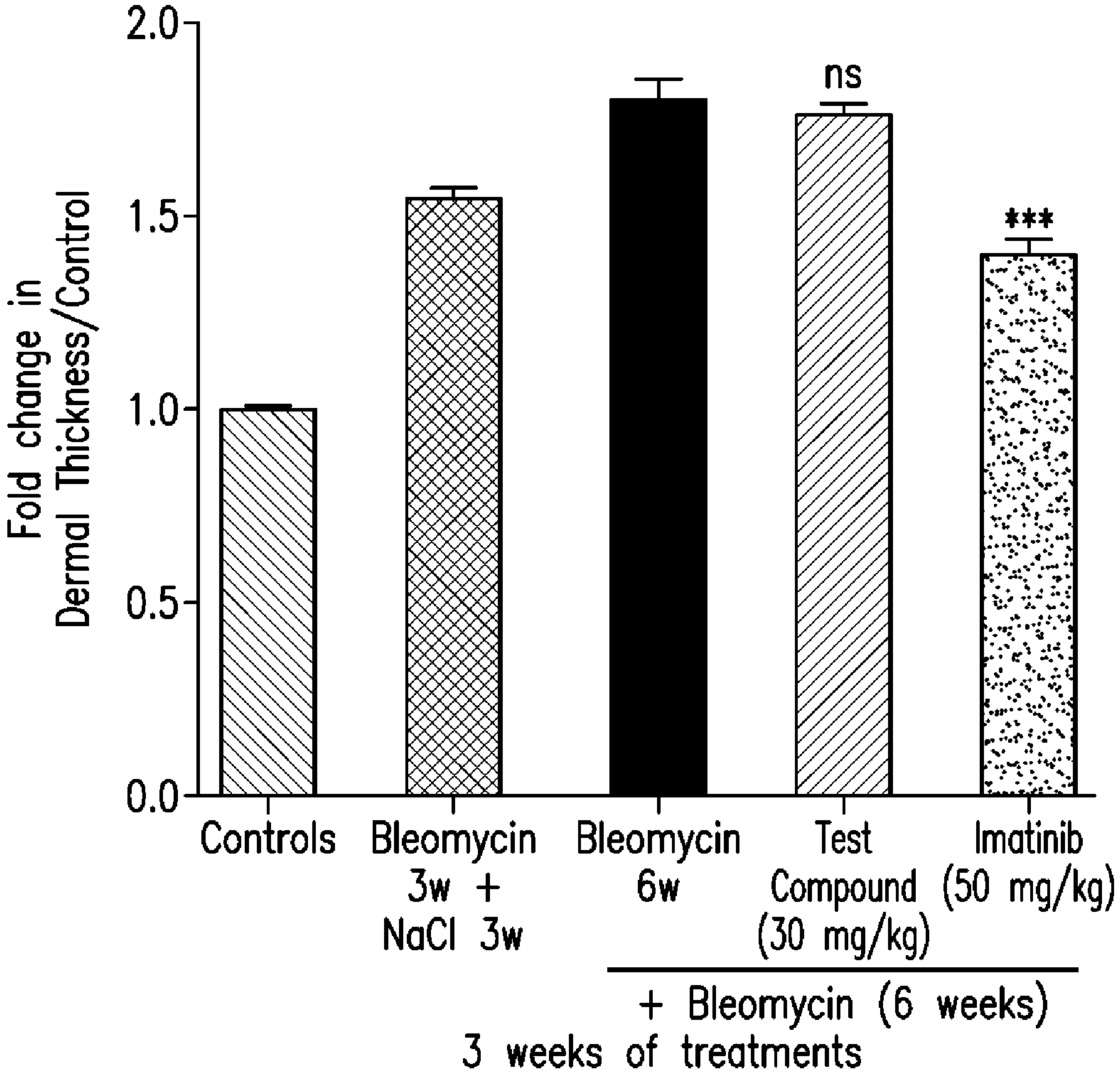
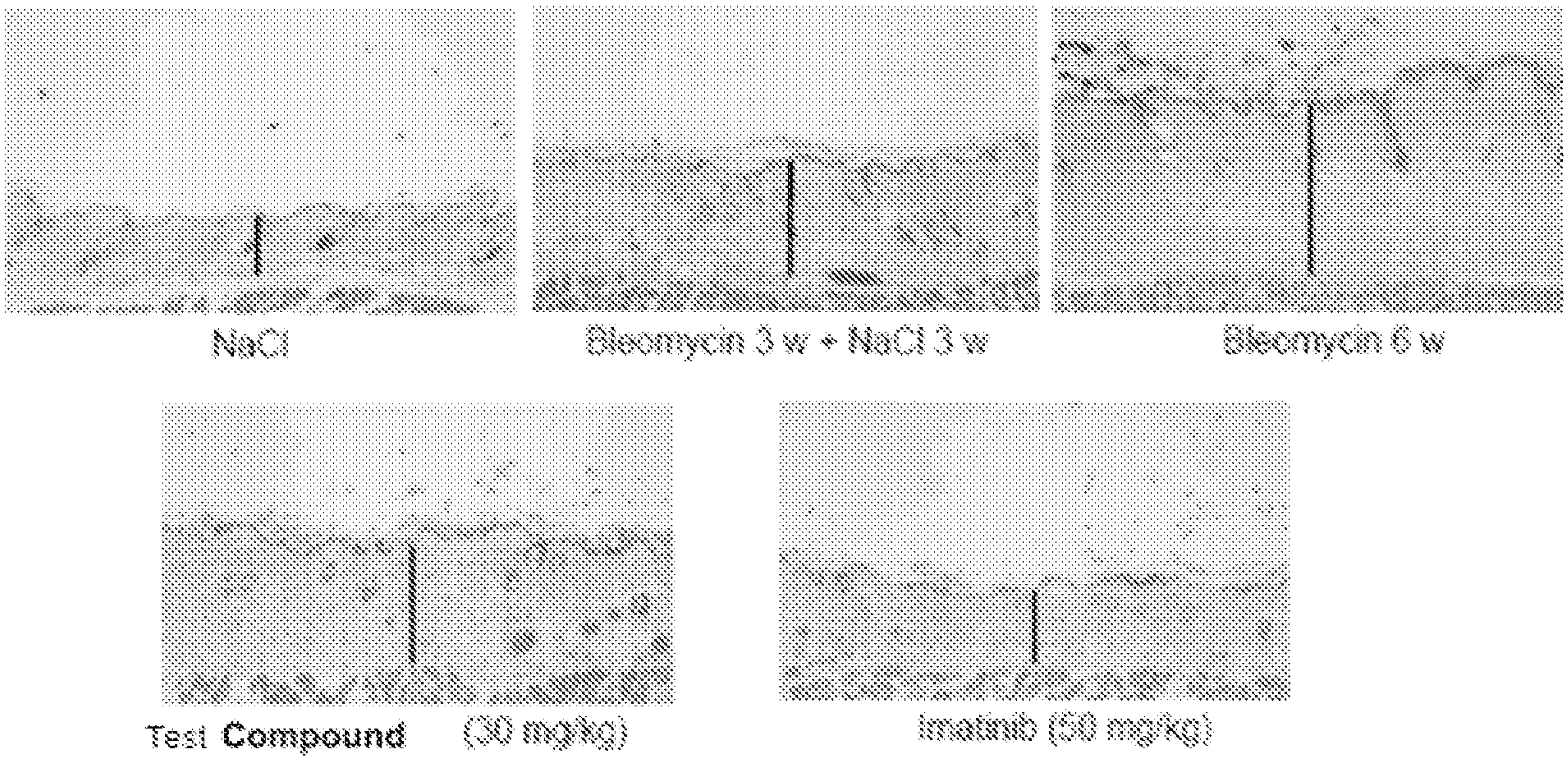
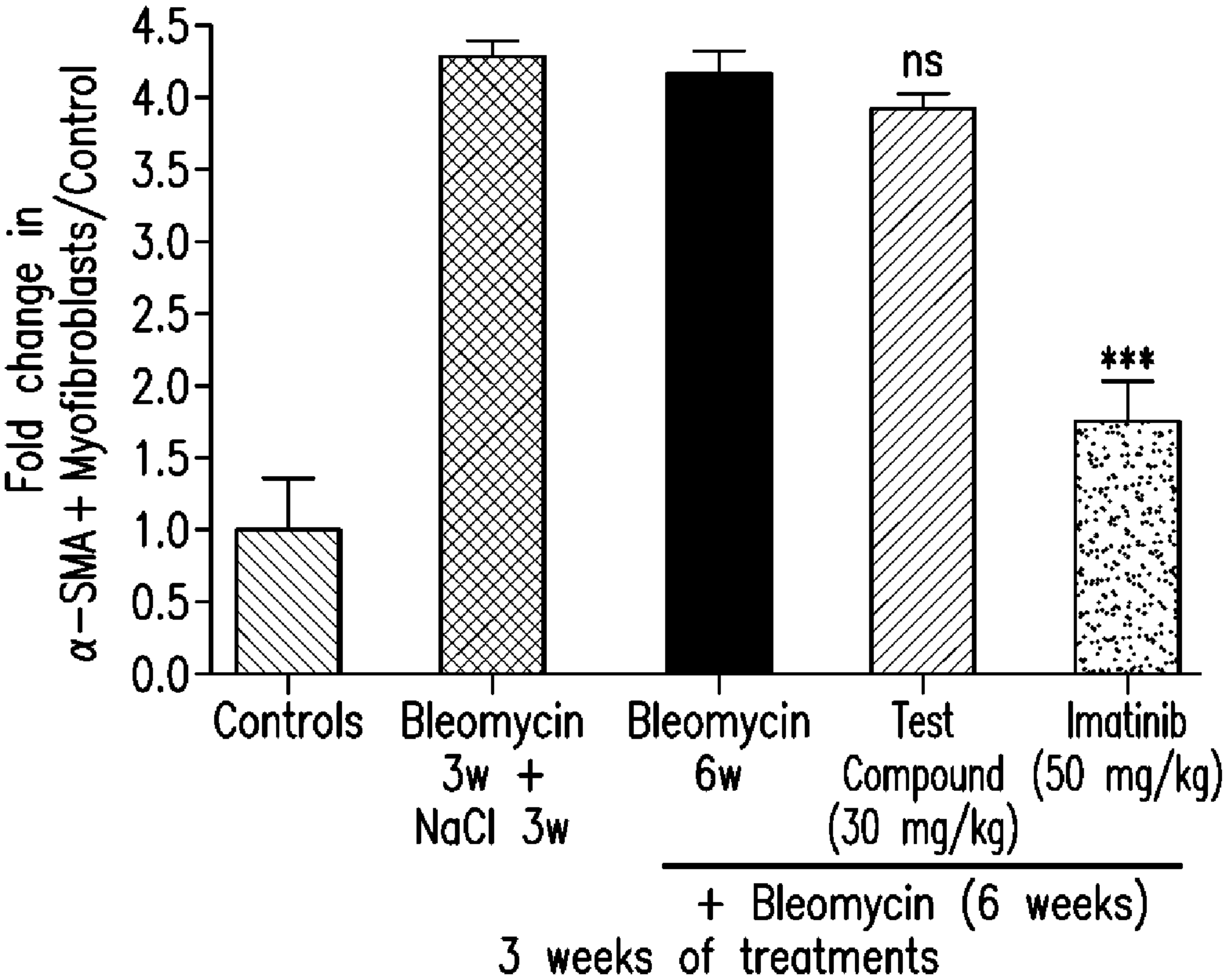

Fold change in Dermal Thickness/Control
2.0
1.5
1.0
0.5
0.0
ns
***
Controls
Bleomycin 3w + NaCl 3w
Bleomycin 6w
Test Compound (30 mg/kg)
Imatinib (50 mg/kg)
+ Bleomycin (6 weeks)
3 weeks of treatments

FIG. 45

FIG. 46


NaCl
Bleomycin 3 w + NaCl 3 w
Bleomycin 6 w
Test Compound (30 mg/kg)
Imatinib (50 mg/kg)



Fold change in
α−SMA + Myofibroblasts/Control
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
ns
***
Controls
Bleomycin 3w + NaCl 3w
Bleomycin 6w
Test Compound (30 mg/kg)
Imatinib (50 mg/kg)
+ Bleomycin (6 weeks)
3 weeks of treatments

FIG. 47

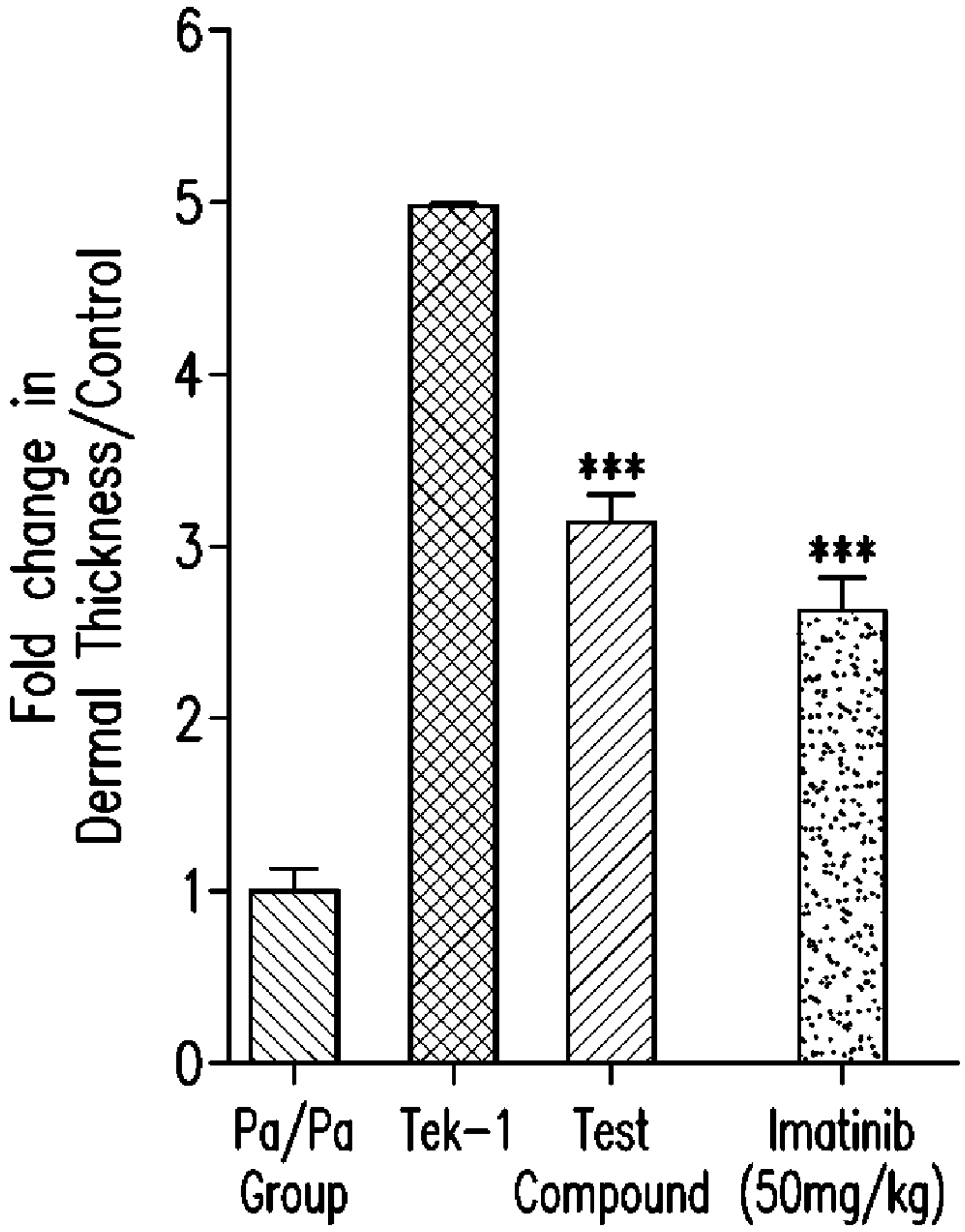


FIG. 48A

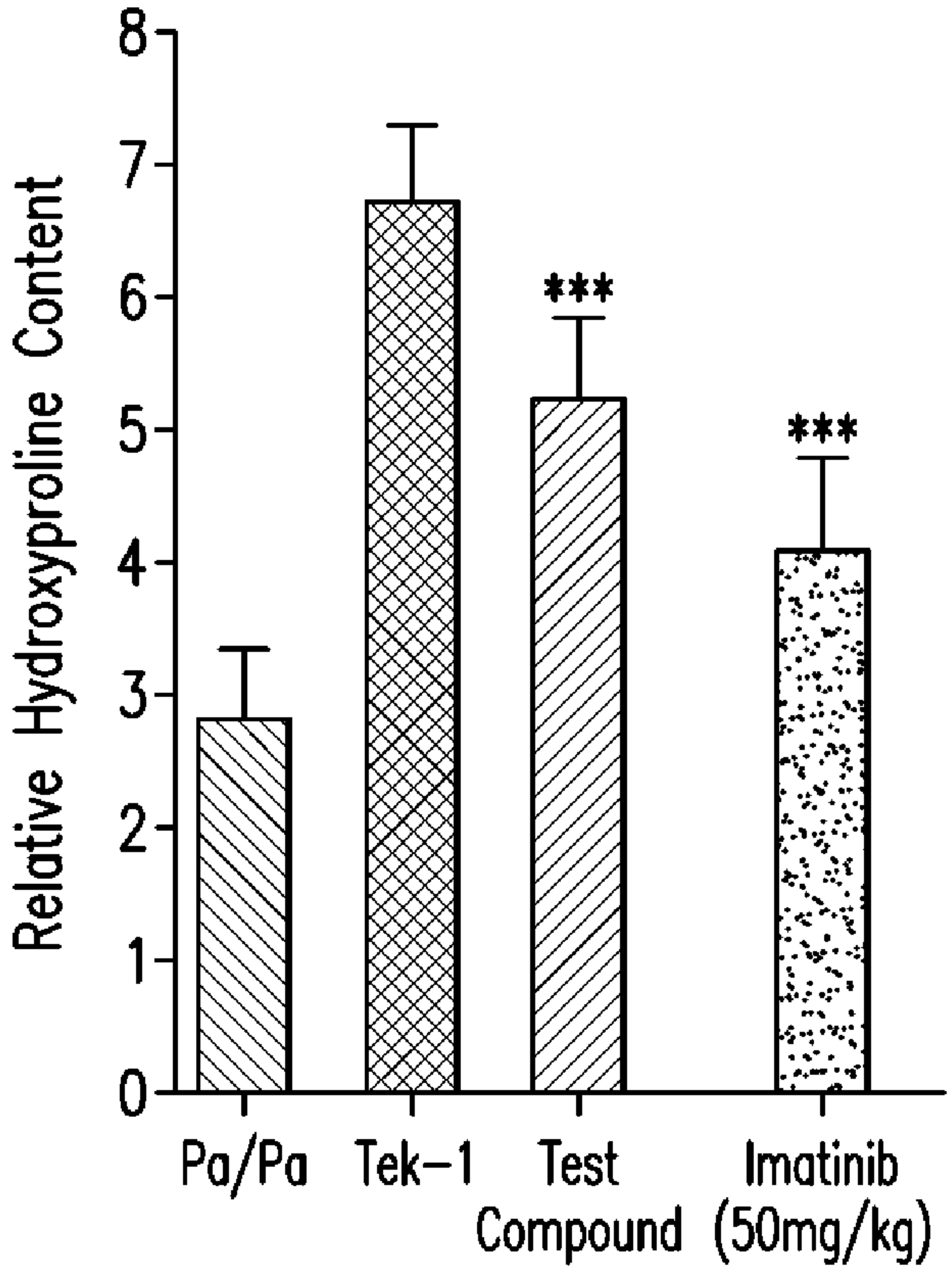
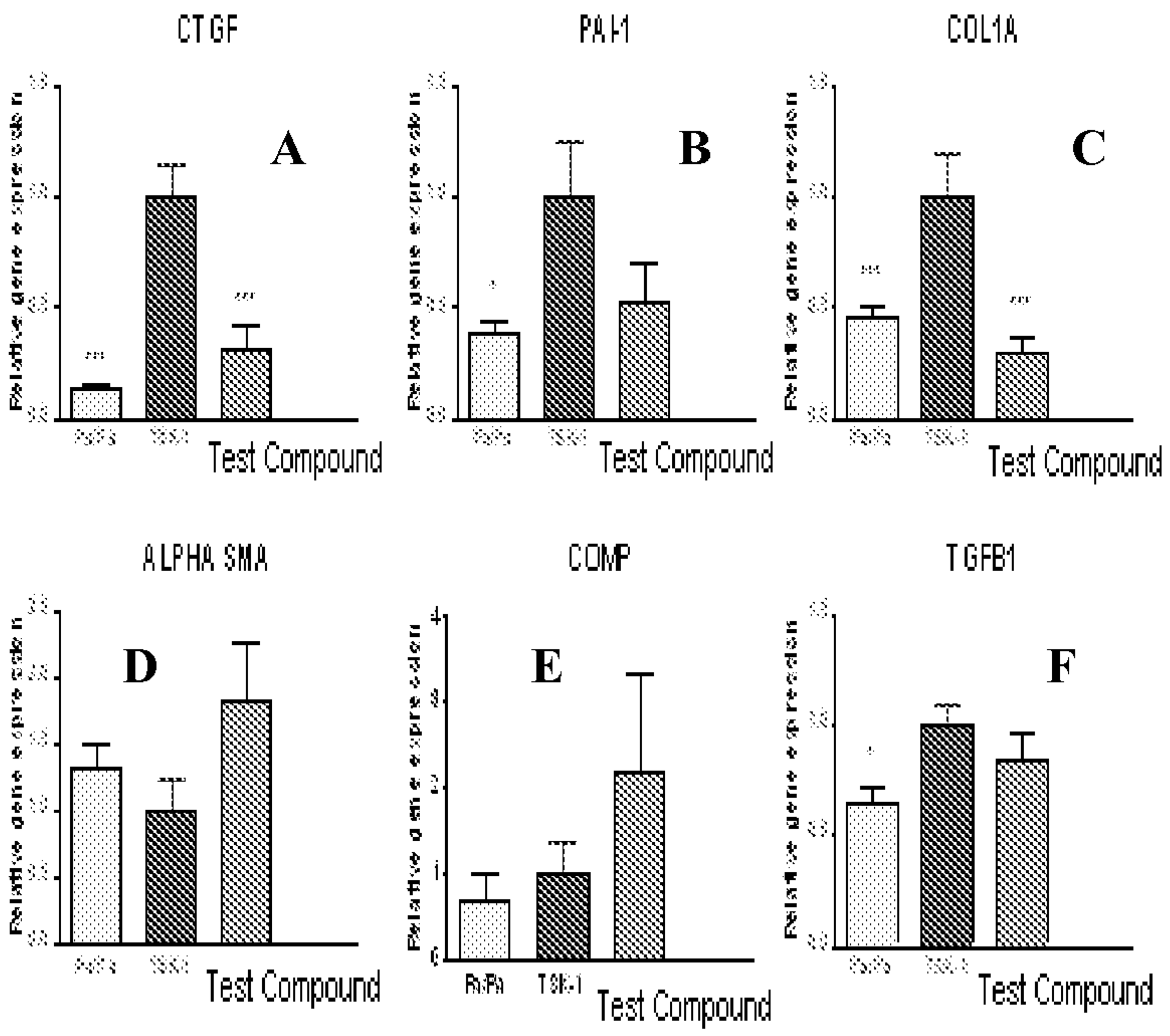


FIG. 48B

FIG. 49


CTGF
A
Relative gene expression
Test Compound
PAI-1
B
Relative gene expression
Test Compound
COL1A
C
Relative gene expression
Test Compound
ALPHA SMA
D
Relative gene expression
Test Compound
COMP
E
Relative gene expression
Pa/Pa
TSK-1
Test Compound
TGFB1
F
Relative gene expression
Test Compound

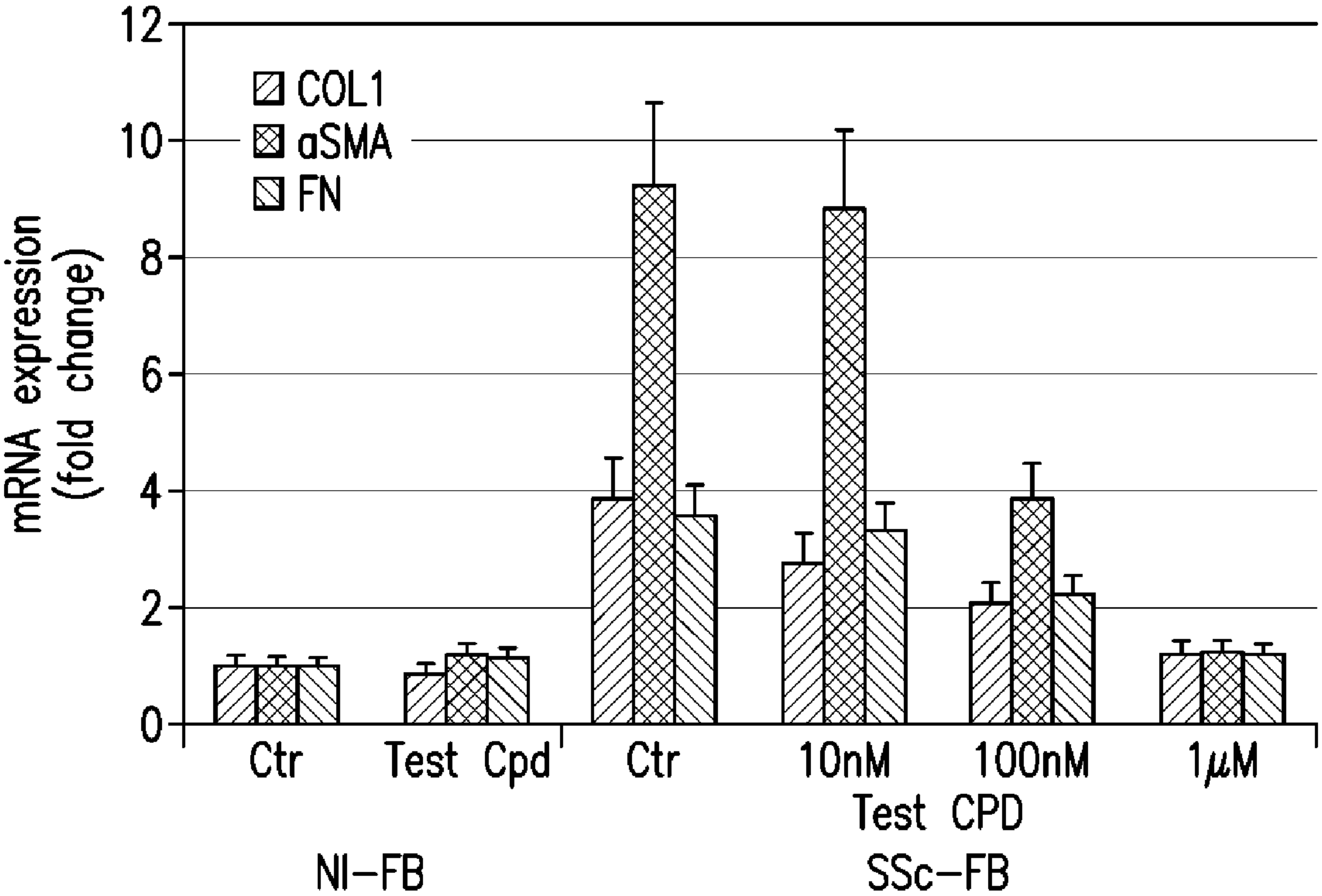

12
10
8
6
4
2
0
mRNA expression
(fold change)
COL1
aSMA
FN
Ctr
Test Cpd
Ctr
10nM
100nM
1μM
Test CPD
NI-FB
SSc-FB

FIG. 50

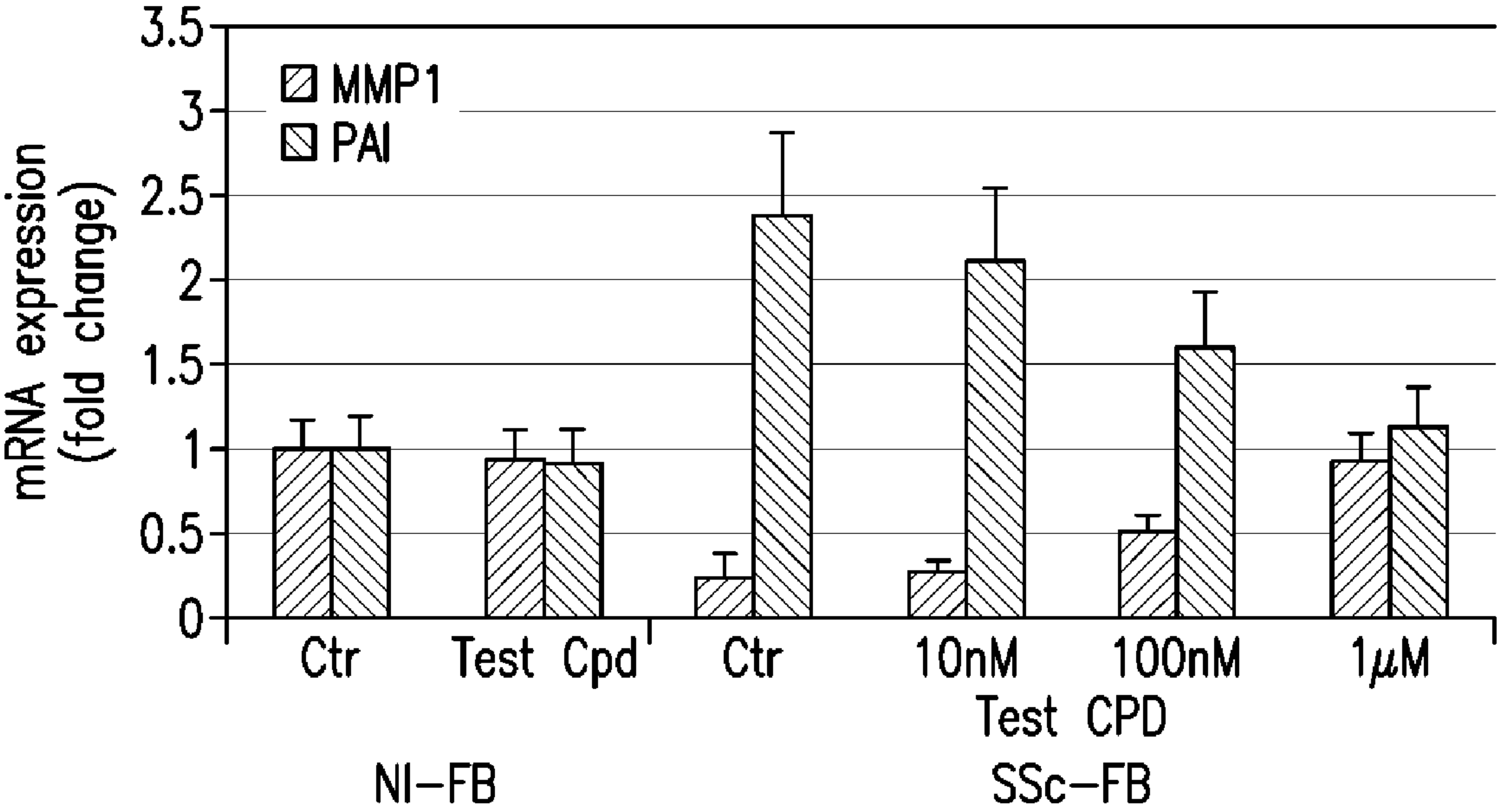

3.5
3
2.5
2
1.5
1
0.5
0
MMP1
PAI
mRNA expression
(fold change)
Ctr
Test Cpd
Ctr
10nM
100nM
1μM
Test CPD
NI-FB
SSc-FB

FIG. 51

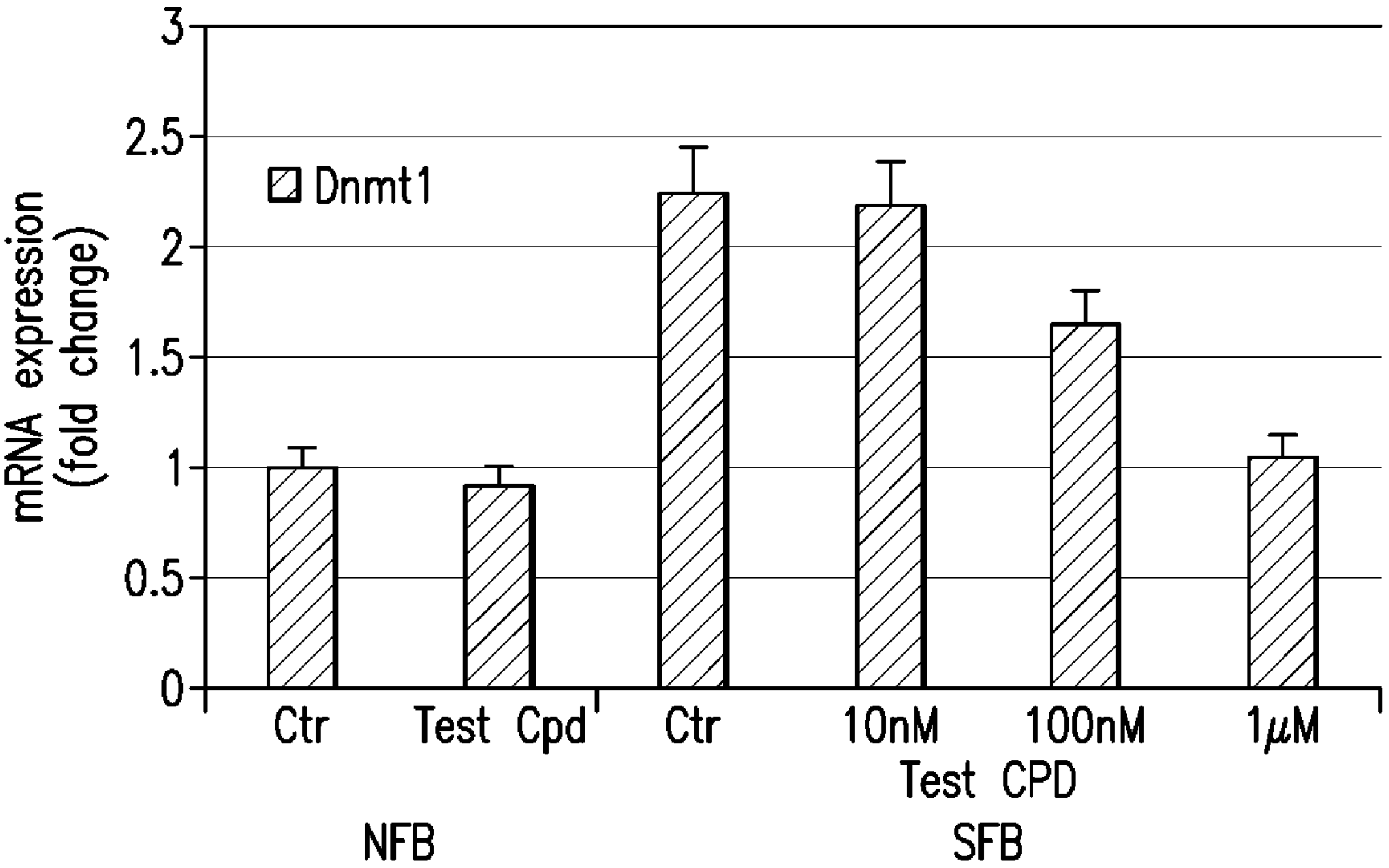

mRNA expression
(fold change)
3
2.5
2
1.5
1
0.5
0
Dnmt1
Ctr
Test Cpd
Ctr
10nM
100nM
1μM
Test CPD
NFB
SFB

FIG. 52

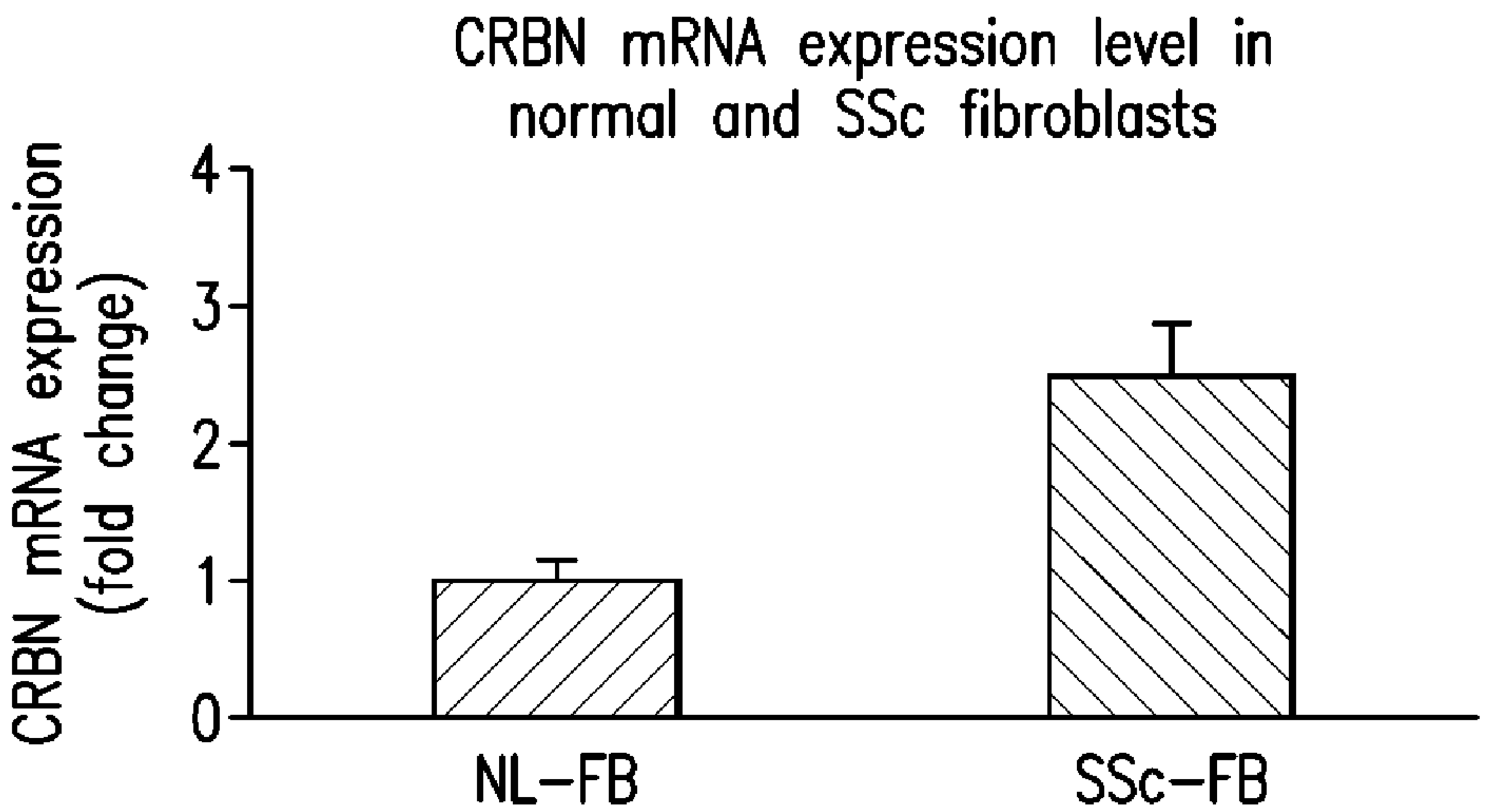

CRBN mRNA expression level in
normal and SSc fibroblasts
CRBN mRNA expression
(fold change)
4
3
2
1
0
NL-FB
SSc-FB

FIG. 53

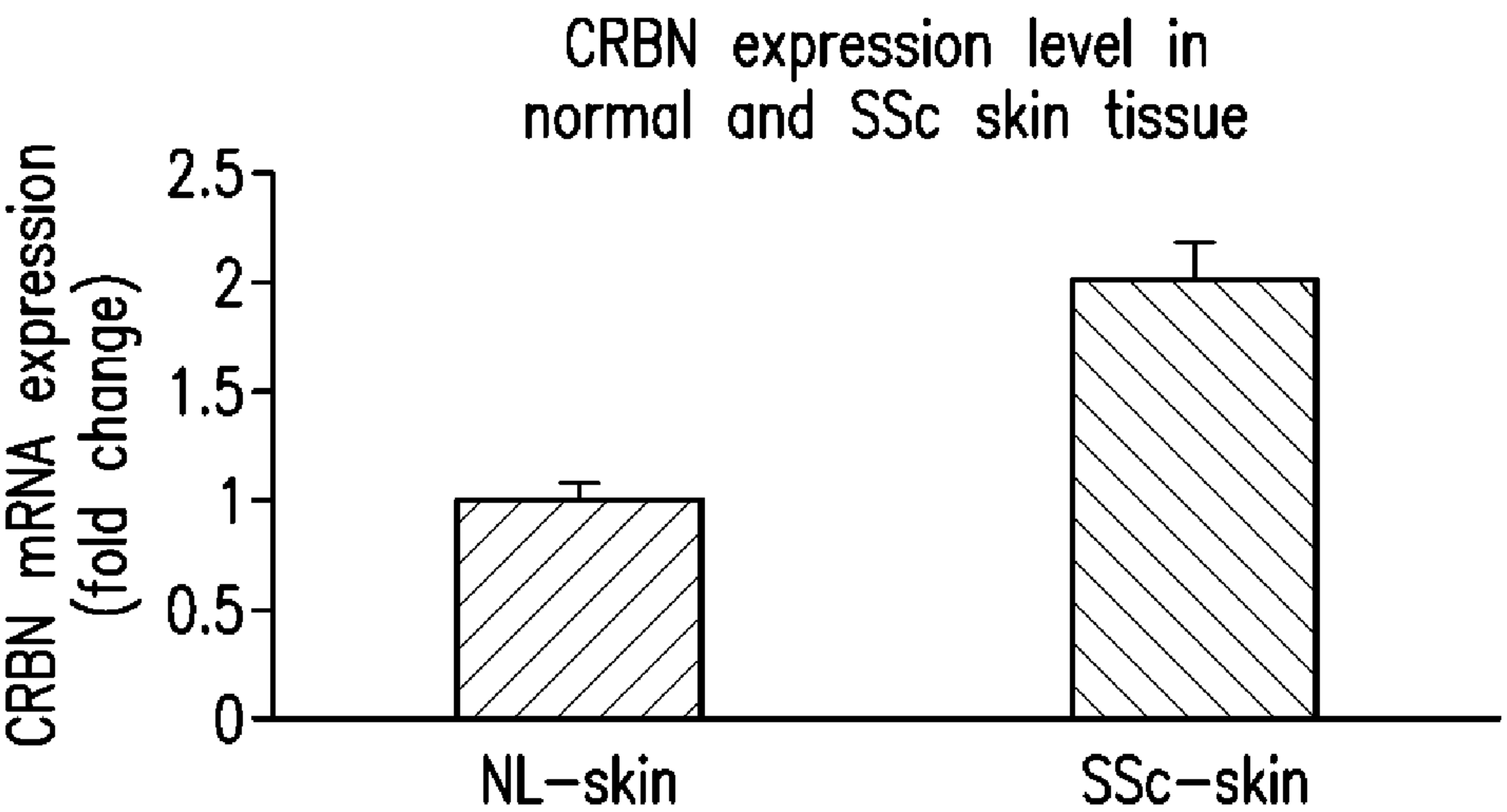
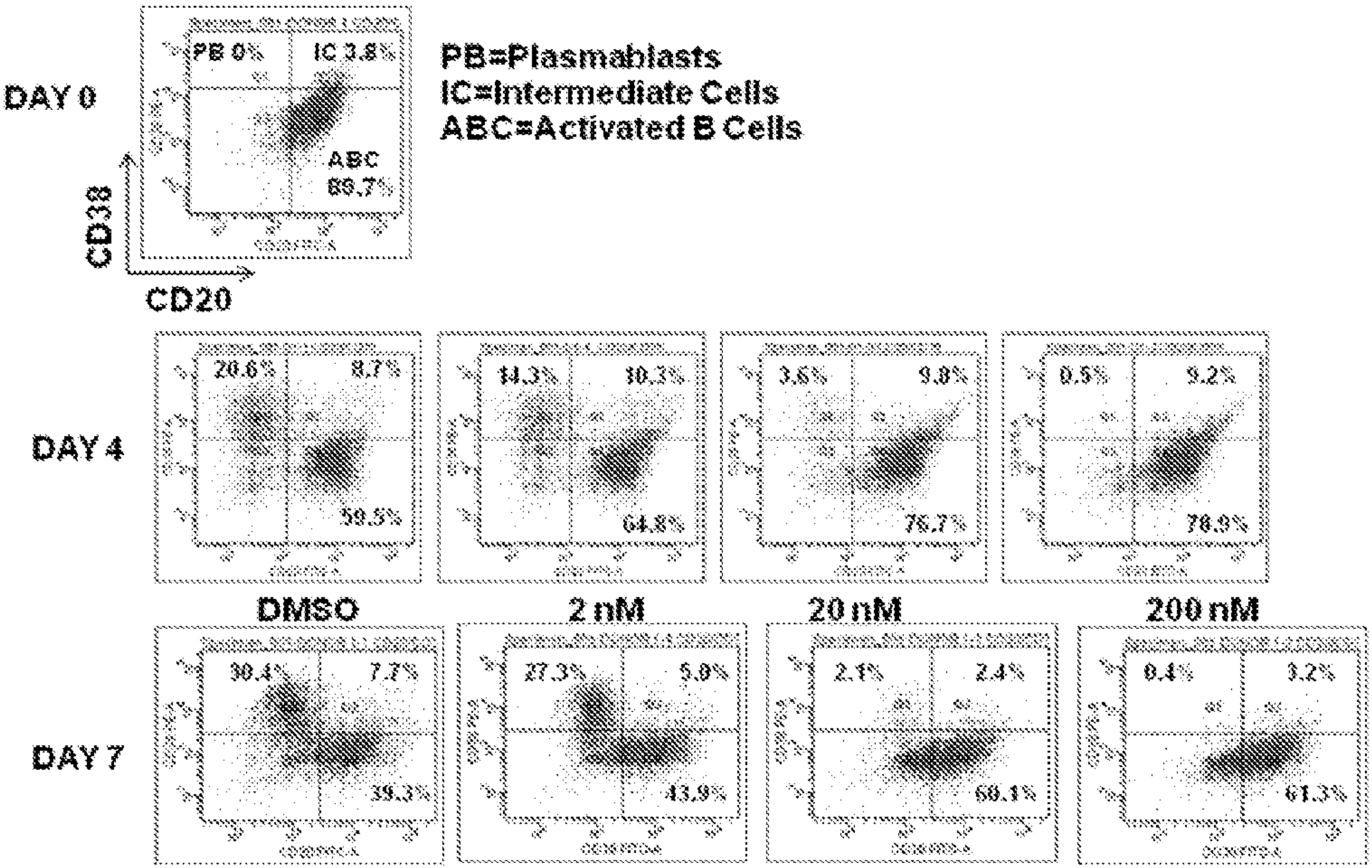

CRBN expression level in
normal and SSc skin tissue
CRBN mRNA expression
(fold change)
2.5
2
1.5
1
0.5
0
NL-skin
SSc-skin

FIG. 54

FIG. 1


DAY 0
PB 0%
IC 3.8%
ABC
89.7%
CD38
CD20
PB=Plasmablasts
IC=Intermediate Cells
ABC=Activated B Cells
DAY 4
20.6%
8.7%
59.5%
14.3%
10.3%
64.8%
3.6%
9.8%
76.7%
0.5%
9.2%
78.9%
DMSO
2 nM
20 nM
200 nM
DAY 7
30.4%
7.7%
39.3%
27.3%
5.8%
43.9%
2.1%
2.4%
68.1%
0.4%
3.2%
61.3%