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- (71) Applicant: QIAGEN GMBH [DE/DE]; Qiagen Strasse 1, 40723 Hilden (DE).
- (72) Inventor: WAHL, Matthais; Qiagen Strasse 1, 40723 Hilden (DE).
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(54) Title: METHOD FOR PROCESSING A WATER-IN-OIL EMULSION

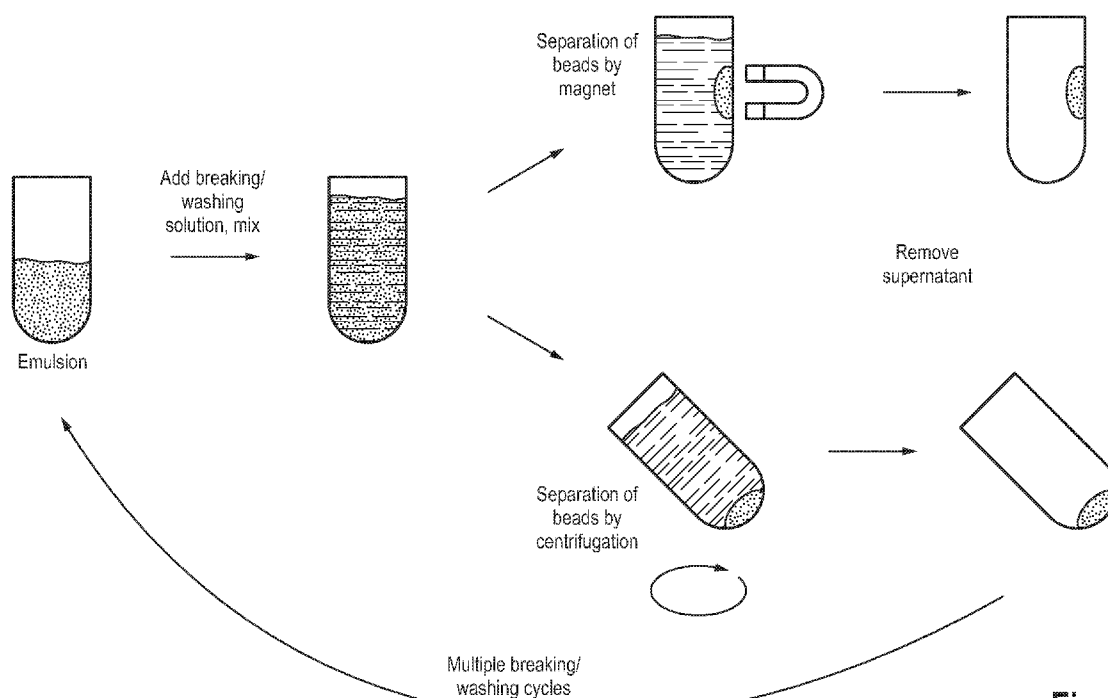


Fig. 1

(57) Abstract: The invention is directed to a novel method, use and kit to be employed for processing a water-in-oil emulsion, e.g. in the context of or subsequent to an emulsion polymerase chain reaction (emPCR).



METHOD FOR PROCESSING A WATER-IN-OIL EMULSION

[0001] The present invention is directed to a method for processing a water-in-oil-emulsion, for example in the context of or subsequent to an emulsion polymerase chain reaction (emPCR).

FIELD OF THE INVENTION

[0002] The present invention relates to the field of molecular biology, more particularly to the amplification of nucleic acid molecules.

BACKGROUND OF THE INVENTION

[0003] In the field of molecular or recombinant biology for many tasks it is necessary to immobilize a large number of DNA molecules on surfaces.

[0004] The polymerase chain reaction (PCR) is a technology in molecular biology used to amplify a single copy or a few copies of a piece of DNA across several orders of magnitude, generating thousands to millions of copies of a particular DNA sequence.

[0005] Recently, PCR-based methods have been adapted to amplifying molecules contained within water-in-oil emulsions. In such amplification methods a plurality of biological samples, e.g. nucleic acid samples, may be individually encapsulated in small aqueous micelles forming reaction compartments in the surrounding oil phase. PCR amplification is conducted on each of the plurality of encapsulated nucleic acid samples simultaneously. Such reaction compartments or microcapsules are often referred to as "microreactors" because the amplification occurs within the reaction compartments. The PCR is then often referred to as emulsion PCR (emPCR).

[0006] The small reaction compartments can include a template bead or microsphere and the amplification process may be referred to as bead-based emulsion PCR. In such a technique, beads along with DNA templates are suspended in an aqueous reaction mixture and then encapsulated in an inverse (water-in-oil) emulsion. The template DNA may be either bound to the bead prior to emulsification or may be included in solution in the amplification reaction mixture. For further details regarding techniques for bead emulsion amplification, reference is made to PCT publication WO 2005/073410 A2 which is incorporated by reference in its entirety herein.

[0007] Emulsion PCR finds a widespread application in molecular diagnostics, such as in the RainDrop[®] Digital PCR System, RainDance Technologies, Inc., Billerica, MA, U.S.A. Additionally, emulsion PCR is being employed for target amplification for several next generation sequencing (NGS) platforms, such as Roche/545, ThermoFisher Scientific Ion Torrent[™], and the QIAGEN GeneReader.

[0008] Subsequent to an emPCR the oil phase is to be removed or the emulsion is to be "broken" in order to isolate the amplified nucleic acids from the reaction compartments. Such process is referred to as the "breaking step".

[0009] To remove the oil phase in the breaking step isopropanol [(CH₃)₂CHOH] and butanol [CH₃(CH₂)₃OH] are the reagents of choice. However, both have severe disadvantages, including light inflammability, acute toxicity, low flash point, causing corrosion, and unpleasant odor.

[0010] Against this background, it is an object of the present invention to provide a new method for breaking a water-in-oil emulsion comprising a plurality of water droplets which include nucleic acid molecules.

[0011] The present invention satisfies these and other needs.

SUMMARY OF THE INVENTION

[0012] The present invention provides a method for processing a water-in-oil emulsion, comprising the following steps:

- 1) providing a water-in-oil emulsion, said emulsion comprises a plurality of aqueous droplets, wherein at least a fraction of said aqueous droplets includes nucleic acid molecules; and
- 2) adding a solution comprising an anionic surfactant to said water-in-oil emulsion to obtain a 'broken solution'.

[0013] The inventor has developed a new method to break an water-in-oil emulsion, preferably in the context of or subsequent to an emulsion PCR, respectively. The method according to the invention may also be understood as a method for breaking such a water-in-oil emulsion. The method according to the invention has numerous advantages over the currently used method in the art.

[0014] The use of an anionic surfactant has numerous advantages over the use of isopropanol or butanol. It is hardly inflammable, non-toxic, doesn't smell, does not cause corrosion. Importantly, the anionic surfactant does not adversely affect the performance of amplified nucleic acid molecules and any downstream enzymatic reactions, such as the sequencing reaction mediated by a sequencing polymerase.

[0015] According to the invention an "anionic surfactant" refers to anionic compounds that lower the surface tension or interfacial tension between two liquids or between a liquid and a solid. Anionic surfactants contain anionic functional groups at their head, such as sulfate, sulfonate, phosphate, and carboxylates. Prominent alkyl sulfates include ammonium lauryl sulfate, sodium lauryl sulfate (SDS, sodium dodecyl sulfate, another name for the compound) and the related alkyl-ether sulfates sodium laureth sulfate, also known as sodium lauryl ether sulfate (SLES), and sodium myreth sulfate.

[0016] According to the invention a "solution" comprising said anionic surfactant refers to a solution which may contain the anionic surfactant dissolved in an appropriate carrier such as a buffer, e.g. TE buffer. It may also refer to a pure anionic surfactant solution.

[0017] According to the invention "aqueous droplets" refer to the aqueous phase of the water-in-oil emulsion consisting of a plurality of small micelles forming compartments in the surrounding oil phase capable of containing nucleic acid molecules. The aqueous droplets may be reaction compartments or microcapsules or "microreactors" for an emulsion PCR.

[0018] According to the invention at least a fraction of the aqueous droplets includes nucleic acid molecules. This means that there may be aqueous droplets without any nucleic acid molecules. However, it may also be the case that all of the aqueous droplets contain nucleic acid molecules. The nucleic acid molecules are in the following also referred to as "nucleic acid molecules of interest". In an embodiment of the invention such nucleic acid molecules may include a template nucleic acid molecule and copies thereof resulting from an amplification method, such as a polymerase chain reaction (PCR).

[0019] According to the invention the nucleic acid molecule may be of any nature, i.e. DNA, RNA, etc., whereas DNA is preferred.

[0020] After the addition of the solution comprising the anionic surfactant the emulsion is "broken" and a "broken solution" is obtained. Such step may include a resuspension or vigorously mixing, e.g. by pipetting (as done on the GeneRead QIAcube) or on a Vortex[®] device, to obtain a homogeneous solution. According to the invention, "breaking" means demulsifying or a demulsification of the water-in-oil emulsion. The breaking or demulsification leads to the complete or partial separation of the water-in-oil emulsion into oil and water layers.

[0021] In an embodiment of the invention the anionic surfactant is selected from the group consisting of: alkyl sulfates and alkyl carboxylates. Preferably, said alkyl sulfate is selected from the group consisting of: ammonium lauryl sulfate, sodium lauryl sulfate, sodium laureth sulfate, sodium myreth sulfate.

[0022] This measure has the advantage that such kind of anionic surfactant is employed which, according to the findings of the inventor, yields especially good results.

[0023] In an embodiment of the invention said solution provides said anionic surfactant in said water-in-oil emulsion in a final concentration of between approx. 1 - 50 wt.-%, preferably approx. 2 - 40 wt.-%, more preferably approx. 3 - 30 wt.-%, more preferably approx. 4 - 20 wt.-%, more preferably approx. 5 - 15 wt.-%, most preferably approx. 10 wt.-%.

[0024] This embodiment has the advantage that said anionic surfactant is added to the water-in-oil emulsion in a concentration which ensures an effective breaking and removal of the oil phase. The skilled person can easily prepare a stock solution comprising the anionic surfactant in the concentration needed in order to end up with the final concentrations as prescribed in this embodiment.

[0025] It is to be understood that the surfactant may be added to the emulsion in several steps where, possibly, different amounts or concentrations may be added. There may be a first step of adding the anionic surfactant in a considerably high concentration and (a) following step(s) of adding the anionic surfactant in a lower concentration, e.g. 10 wt.-% followed by 5 wt.-%, possibly with a washing steps in between.

[0026] In an embodiment of the invention said fraction of said aqueous droplets containing nucleic acid molecules includes one or more solid carriers, preferably micropheres, capable of capturing said nucleic acid molecules.

[0027] This measure has the advantage that the structural preconditions are established for using the invention in the context of or subsequent to a traditional emulsion PCR. "Capable of capturing" includes a state where the nucleic acid molecules are actually captured by the solid carriers. In an embodiment of the invention the capability can be established, e.g., by providing the solid carriers with nucleic acid molecules comprising a nucleotide sequence complementary to the nucleotide sequence of the nucleic acid molecule of interest. The nucleic acid molecule of interest can then be anchored to the solid carrier.

[0028] According to the invention a "solid carrier" refers to a physical entity allowing the adhesion of a nucleic acid. A preferred solid carrier is a microsphere which is traditionally used in an emulsion PCR. In the following the term "bead" is interchangeably used for "microsphere".

[0029] The inventor has surprisingly found out that the microspheres and the adhering nucleic acid molecules are not adversely affected by the anionic surfactant.

[0030] Examples of suitable microspheres or beads are superparamagnetic spherical polymer particles ("magnetic beads"), for example Thermo Fischer Scientific Dynabeads® Magnetic Beads, polymer beads, for example polystyrene beads or polyacrylamide beads, silica beads, agarose beads.

[0031] The interaction between the solid carrier and nucleic acid molecules to capture the latter to the carrier may be mediated by covalent bonds, e.g. capture nucleic acid molecules are covalently bound to the solid carrier's surface, or by high non-covalent affinity interaction, e.g. between biotin and streptavidin.

[0032] According to a preferred embodiment in the method of the invention the following further step (3) is carried out:

- 3) separating said solid carriers together with captured nucleic acid molecules from said 'broken solution'.

[0033] This further step allows the recovering of the captured nucleic acid molecules by removing the solid carriers, e.g. microspheres, with the nucleic acid molecules attached thereto, from the solution. This separation step may include the washing of the solid carriers together with captured nucleic acid molecules to remove residual traces of the oil phase from the nucleic acid molecules.

[0034] According to a preferred embodiment in the method of the invention after step (2) and before step (3) the following further step (2.1) is carried out:

- 2.1) mixing the 'broken solution'.

[0035] This measure ensures an effective disintegration of the water-in-oil emulsion. The mixing can be realized by a resuspension, e.g. by pipetting (as done in the GeneRead QIAcube) or vigorously shaking, e.g. on a Vortex[®] device, to obtain a homogeneous solution.

[0036] According to an embodiment of the invention said microspheres comprise magnetic properties.

[0037] This measure has the advantage that a convenient and simple separation of the captured nucleic acids can be achieved by applying a magnetic field to the broken solution.

[0038] In a preferred embodiment of the method according to the invention said separation occurs by sedimenting said solid carriers together with captured nucleic acid molecules, preferably via centrifugation of said broken solution.

[0039] This measure takes advantage of a common separation technology for separating solid particles from a liquid phase.

[0040] In a preferred embodiment of the method according to the invention where the solid carrier comprises magnetic properties said separation occurs via the application of a magnetic field to said broken solution.

[0041] This measure incorporates a well-established technology for separating magnetic microspheres from a liquid phase.

[0042] In a further development of the method according to the invention the supernatant is removed and said nucleic acid molecules are recovered.

[0043] This step ensures the isolation of the nucleic acid molecules adhered to the solid carriers.

[0044] Said recovering may be realized via an enrichment of solid carriers capturing said nucleic acid molecules over such solid carriers not capturing said nucleic acid molecules. This enrichment step can be realized by filtering the solid carriers through a filter having pores with a size allowing a passing-through of solid carriers not capturing said nucleic acid molecules but a withhold of solid carriers capturing said nucleic acid molecules. Preferably said filtering is carried out after complexing solid carriers capturing said nucleic acid molecules with 'enrichment beads'. Such 'enrichment beads' may be provided with streptavidin, whereas the nucleic acids of interest captured by the solid carrier may be provided with a biotin modification. The complexing of the solid carriers capturing said nucleic acid molecules with 'enrichment beads' is then realized via a streptavidin-biotin interaction.

[0045] In another embodiment the method according is carried out subsequent to an emulsion polymerase chain reaction (emPCR).

[0046] This measure results in an improvement of the current emPCR by avoiding isopropanol and butanol. The breaking step in or subsequent to an emPCR as currently carried out in the art is the most critical step. Here, the invention provides effective remedy.

[0047] Another subject-matter of the invention is the use of an anionic surfactant for breaking a water-in-oil emulsion, said emulsion comprises a plurality of water droplets, wherein at least a fraction of said water droplets include nucleic acid molecules.

[0048] The features, characteristics, advantages and embodiments specified for the method according to the invention apply likewise to the use according to the invention.

[0049] Another subject-matter of the present invention relates to a kit for carrying out an emulsion polymerase chain reaction (emPCR) with a nucleic acid molecule of interest comprising an anionic surfactant for breaking a water-in-oil emulsion and an experimental manual.

[0050] A kit is a combination of individual elements useful for carrying out the methods of the invention, wherein the elements are optimized for use together in the methods. The kits also contain additional reagents, chemicals, buffers, reaction vials etc. which may be useful for carrying out the method according to the invention. Such kits unify all essential elements required to work the method according to the invention, thus minimizing the risk of errors. Therefore, such kits also allow semi-skilled laboratory staff to perform the method according to the invention.

[0051] The features, characteristics, advantages and embodiments specified for the method according to the invention apply likewise to the kit according to the invention.

[0052] It is to be understood that the before-mentioned features and those to be mentioned in the following cannot only be used in the combination indicated in the respective case, but also in other combinations or in an isolated manner without departing from the scope of the invention.

[0053] The invention is now further explained by means of embodiments resulting in additional features, characteristics and advantages of the invention. The embodiments are of pure illustrative nature and do not limit the scope or range of the invention. The features mentioned in the specific embodiments are general features of the invention which are not only applicable in the specific embodiment but also in an isolated manner in the context of any embodiment of the invention.

[0054] The invention is now described and explained in further detail by referring to the following non-limiting examples and drawings.

- Fig. 1: shows a flow chart illustrating an embodiment of the method according to the invention and the subsequent steps;
- Fig. 2: shows a flow chart illustrating another embodiment of the method according to the invention and the subsequent enrichment of monoclonal beads via complexing them to 'enrichment beads';
- Fig. 3: shows a comparison of an embodiment of the method according to the invention with the prior art method in respect of (A) sequencing performance, (B) enrichment, and (C) recovery.

Examples

1. Method according to the invention

[0055] In Fig. 1 the method according to the invention and the subsequent steps are illustrated by means of an embodiment. An emulsion is provided where aqueous reaction compartments are separated by an oil phase. Those reaction compartments or droplets contain all reagents necessary for an PCR amplification and, ideally, one single library fragment. Usually, the PCR is carried out on the surface of microspheres or beads which capture the target and amplified nucleic acids. The PCR is also referred to as emulsion PCR (emPCR).

[0056] After the emPCR has been carried out buffer containing an anionic surfactant is added to the emulsion, e.g. 10 wt.-% ammonium lauryl sulfate (ALS) in the final concentration. The oil phase is then 'broken' by resuspending or vigorously mixing the emulsion after emPCR.

[0057] In case of using magnetic microspheres a magnetic field is applied to the broken solution resulting in the confining of the microspheres in the sphere of the magnetic field. The supernatant is removed. Alternatively or additionally the microspheres can be spun down by centrifuging the broken solution, followed by a removal of the supernatant.

[0058] The microspheres are then washed to remove residual traces of the oil phase by resuspending or vigorously mixing the beads with different wash buffers followed by the removal of the supernatant. Whereas the "breaking step" may consist of only one cycle of breaking with the anionic surfactant (e.g. 10 wt.-% ALS) multiple washing cycles may follow, e.g. by first using 2 wt.-% ALS in TE buffer and then TE buffer only.

[0059] In Fig. 2 another embodiment of the method according to the invention is illustrated focusing of the subsequent enrichment steps.

[0060] One feature of the methodologies commonly used for emulsion making which include, among others, pipetting, stirring, porous membranes, or microfluidic devices, is that DNA or library fragments thereof, respectively, are

statistically distributed over the droplets. In order to minimize droplets with multiple library fragments which would lead to non-clonally amplified libraries which cannot be sequenced, library fragments are diluted so that a large subset of droplets do not contain a library fragment.

[0061] In next generation sequencing platforms using emulsion PCR for clonal amplification of library fragments on sequencing beads, including IonTorrent and 454, this leads to a large subset of beads that do not contain any library fragment/DNA.

[0062] Those beads without DNA, so called "null beads", in turn would reduce the output of the subsequent sequencing reaction. Therefore, null beads are removed in a process called enrichment. The efficiency of the enrichment step is of high relevance as it helps maximizing the output of a NGS system by reducing non-informative beads w/o DNA.

[0063] In Fig. 2A a monoclonal bead in a droplet of a reaction compartment is shown next to a bead without an amplicon or a "null bead" in another reaction compartment. The reaction compartments are surrounded and separated by the oil phase.

[0064] In the subsequent breaking step an anionic surfactant is added to the emulsion to remove the oil phase and the beads are recovered.

[0065] Beads with an amplicon, so called "live beads", are enriched, beads without an amplicon ("null beads") are depleted. Enrichment beads with a diameter of ~15 μm are used that specifically bind to live beads through a biotin-streptavidin interaction. Biotin is present on the reverse primer and will be only on beads if a PCR amplification has happened. Streptavidin is present on capture beads. The complexing of the live beads with the enrichment beads results in large complexes. The mixture is then subjected to an "enrichment column" having a nylon mesh with a pore size of ~11 μm . The null beads can pass the en-

richment column whereas the live beads complexed to the enrichments beads are withheld and, therefore, enriched due to the large size of the complexes.

[0066] The live beads are then released from the enrichment beads by denaturation, e.g. via treatment with NaOH.

2. Experiments demonstrating the effectivity of the invention

2.1 Material and methods

Library/DNA template

[0067] A barcoded gene panel template was used as the sample for the evaluation. NGHS-101X Clinically Relevant Tumor Panel library was prepared from human control DNA NA12878 (Coriell Institute) using the standard GeneRead™ Library Preparation method. Libraries with barcodes were used in order to enable pooling of multiple samples so that they could be run in a single flowcell.

Experimental procedure

[0068] Droplet making and emulsion PCR cycling was performed as described in the GeneRead™ Clonal Amp Q Kit and GeneRead™ QIAcube manuals. After emulsion PCR, emulsions were manually pooled into 50 ml tubes (i.e. the content of 48 wells which correspond to a sample).

[0069] Next, samples were split into two groups. The first group was broken twice (addition of breaking solution followed by thorough mixing and centrifugation/magnetic separation to collect beads) with isopropanol and the second group was broken twice with a 2:1 mix of 30% ammonium lauryl sulfate and TE (→ final ALS concentration: 10%).

[0070] After that initial breaking, the samples were manually processed using the GeneRead™ Clonal Amp Q Kit (i.e. performing the same steps that are normally conducted by the GeneRead™ QIAcube), with modifications (two additional wash steps and an treatment with exonuclease I). Finally, samples were subjected to a sequencing run on the GeneReader™ using the GeneRead™ Sequencing Q kit (using earlier internal versions which slightly differ from the launch configuration).

QC assay for bead recovery: light scatter assay

[0071] To evaluate the performance of both alternative methods for breaking, intermediates were analyzed after breaking and enrichment using a light scatter assay. Light scattering of beads was measured at OD600 relative to a known standard in order to evaluate the recovery.

QC assay for assessing enrichment efficiency based on flow cytometry (FACS)

[0072] Beads were hybridized with a fluorescent oligonucleotide that specifically binds beads with amplicon. In this way, the fraction of amplicon positive beads could be measured by flow cytometry.

2.2 Results

[0073] In order to assess the applicability of a 10 wt.-% ALS solution in breaking emulsions, an experiment was set up where a total of 8 independent emulsion PCR samples were broken with 10 wt.-% ALS and Isopropanol (prior art method), respectively (8 replicates for each condition; 16 in total). After breaking, all 16 samples were subjected to the GeneReader workflow (washing, enrichment and sequencing followed by an analysis of primary sequencing parameters).

Sequencing performance

[0074] As shown in Fig. 3A, it results that beads or microspheres isolated from an emulsion which was broken with 10 wt.-% ALS show a sequencing performance similar to such obtained with beads/microspheres isolated from an emulsion which was broken by the prior art method.

Enrichment

[0075] As depicted in Fig. 3B, it turns out that beads/microspheres isolated from an emulsion which was broken with 10 wt.-% ALS exhibit an enrichment factor which is better than that obtained with beads/microspheres isolated from an emulsion which was broken by the prior art method. The output is, therefore, better than with the prior art method.

Recovery

[0076] As demonstrated in Fig. 3C, beads/microspheres isolated from an emulsion which was broken with 10 wt.-% ALS show sufficient recovery after breaking and enrichment, i.e. less unspecific beads/microspheres.

Claims

1. A method for processing a water-in-oil emulsion, comprising the following steps:
 - 1) providing a water-in-oil emulsion, said emulsion comprises a plurality of aqueous droplets, wherein at least a fraction of said aqueous droplets includes nucleic acid molecules; and
 - 2) adding a solution comprising an anionic surfactant to said water-in-oil emulsion to obtain a 'broken solution'.
2. The method of claim 1, characterized in that said anionic surfactant is selected from the group consisting of: alkyl sulfates and alkyl carboxylates.
3. The method of claim 2, characterized in that said alkyl sulfate is selected from the group consisting of: ammonium lauryl sulfate, sodium lauryl sulfate, sodium laureth sulfate, sodium myreth sulfate.
4. The method of any of claims 1-3, characterized in that said solution provides said anionic surfactant in said water-in-oil emulsion in a final concentration of between approx. 1 - 50 wt.-%, preferably approx. 2 - 40 wt.-%, more preferably approx. 3 - 30 wt.-%, more preferably approx. 4 - 20 wt.-%, more preferably approx. 5- 15 wt.-%, most preferably approx. 10 wt.-%.
5. The method of any of claims 1-4, characterized in that said fraction includes one or more solid carriers capable of capturing said nucleic acid molecules.
6. The method of claim 5, characterized in that the following further step (3) is carried out:
 - 3) separating said solid carriers together with captured nucleic acid molecules from said 'broken solution'.

7. The method of claim 5 or 6, characterized in that after step (2) and before step (3) the following further step (2.1) is carried out:
 - 2.1) mixing the 'broken solution'.
8. The method of any of claims 5-7, characterized in that said solid carriers are microspheres, preferably said microspheres comprise magnetic properties.
9. The method of any of claims 5-8, characterized in that said separation occurs by sedimenting said solid carriers together with captured nucleic acid molecules, preferably via a centrifugation of said broken solution.
10. The method of claim 8 or 9, characterized in that said separation occurs via the application of a magnetic field to said broken solution.
11. The method of claim 9 or 10, characterized in that the supernatant is removed and said nucleic acid molecules are recovered.
12. The method of claim 11, characterized in that said recovering is realized via an enrichment of solid carriers capturing said nucleic acid molecules over such solid carriers not capturing said nucleic acid molecules, preferably by filtering the solid carriers through a filter configured to allow a passing-through of such solid carriers not capturing said nucleic acid molecules but a withhold of solid carriers capturing said nucleic acid molecules, further preferably said filtering is carried out after complexing solid carriers capturing said nucleic acid molecules with 'enrichment beads'.
13. The method of any of claims 1-11, characterized in that it is carried out subsequent to an emulsion polymerase chain reaction (emPCR).

14. Use of an anionic surfactant for breaking a water-in-oil emulsion, said emulsion comprises a plurality of water droplets, wherein at least a fraction of said water droplets include nucleic acid molecules.
15. Kit for carrying out an emulsion polymerase chain reaction (emPCR) with a nucleic acid molecule of interest comprising an anionic surfactant for breaking an water-in-oil emulsion and an experimental manual.

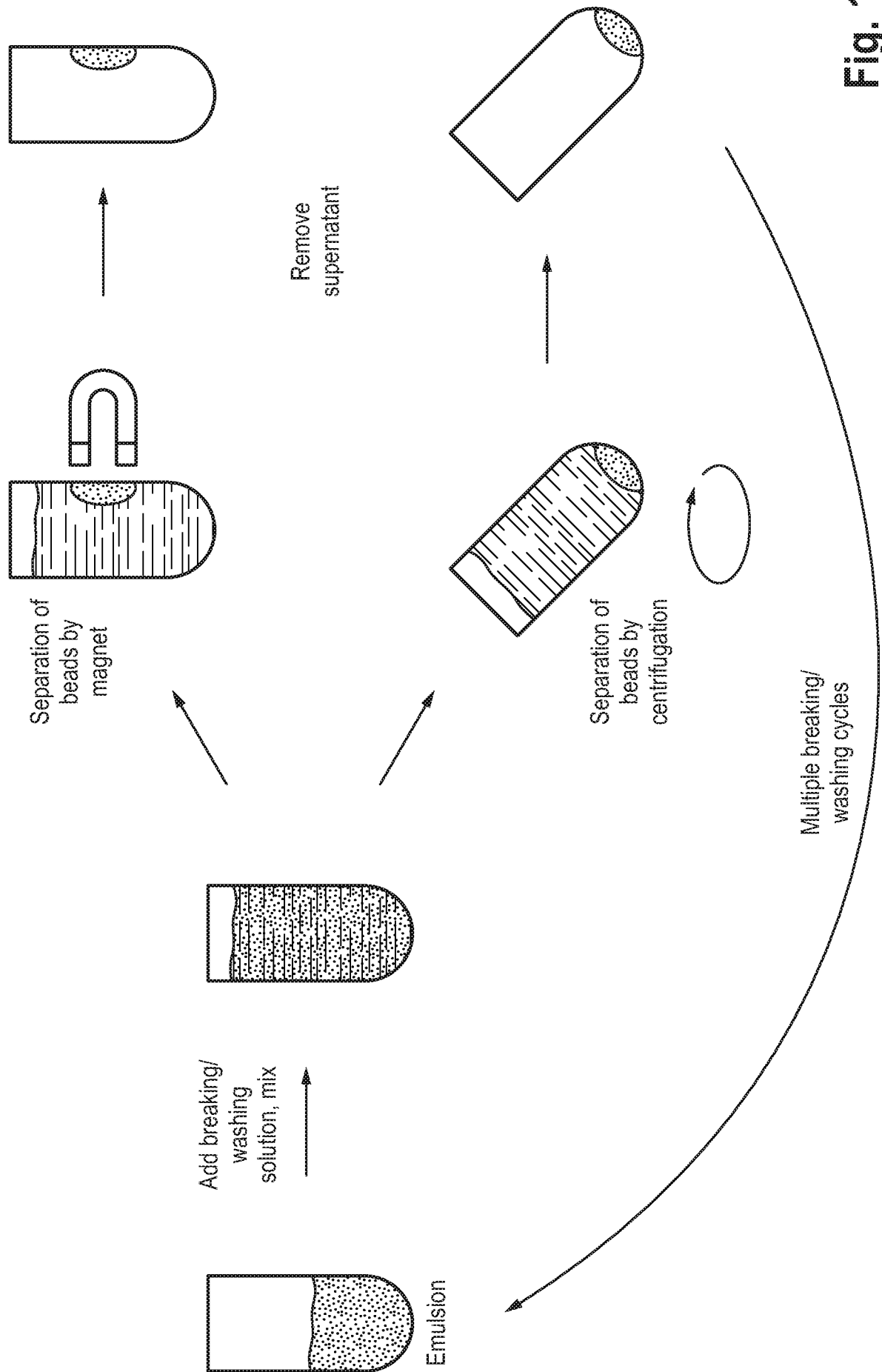


Fig. 1

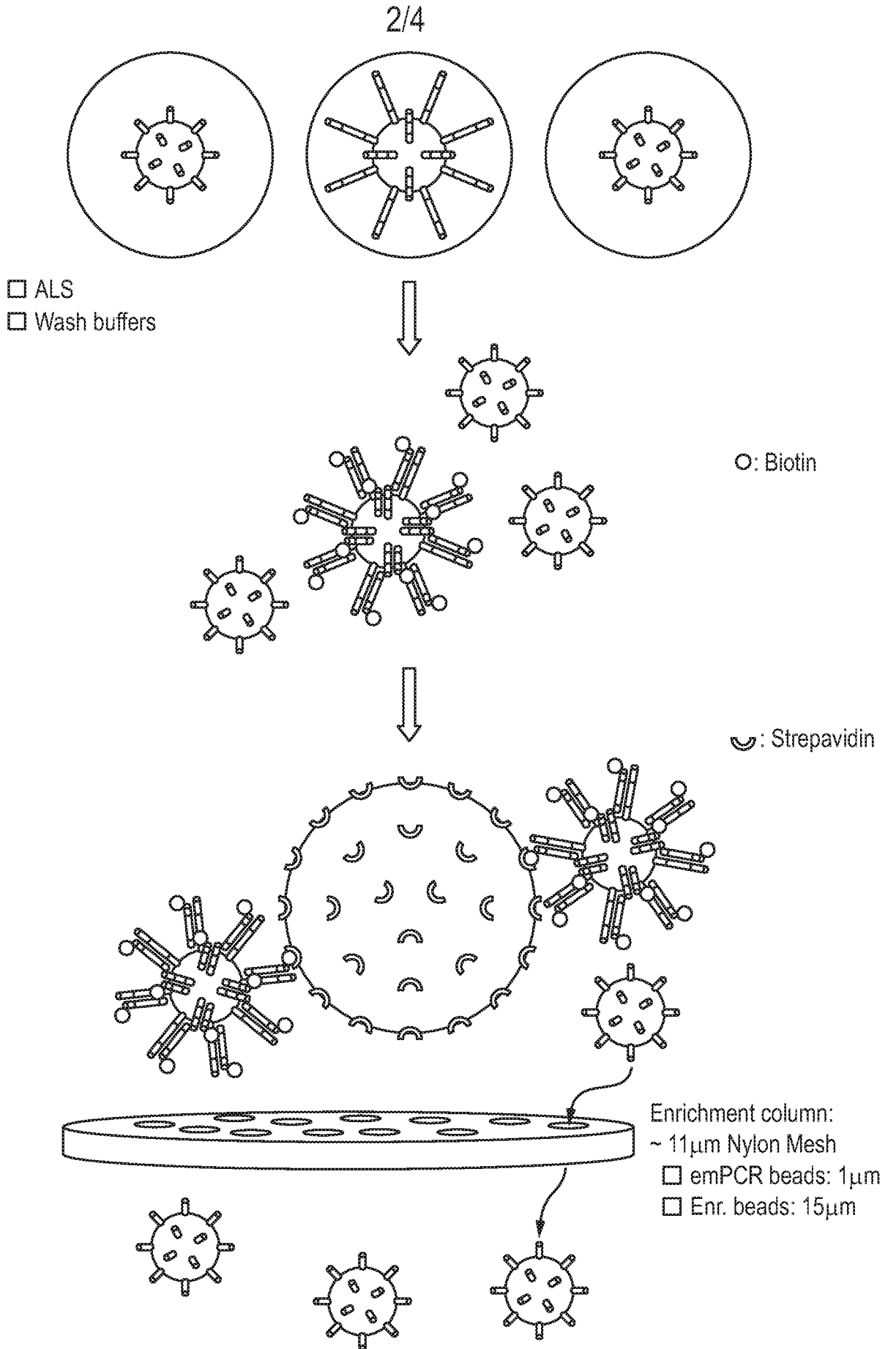
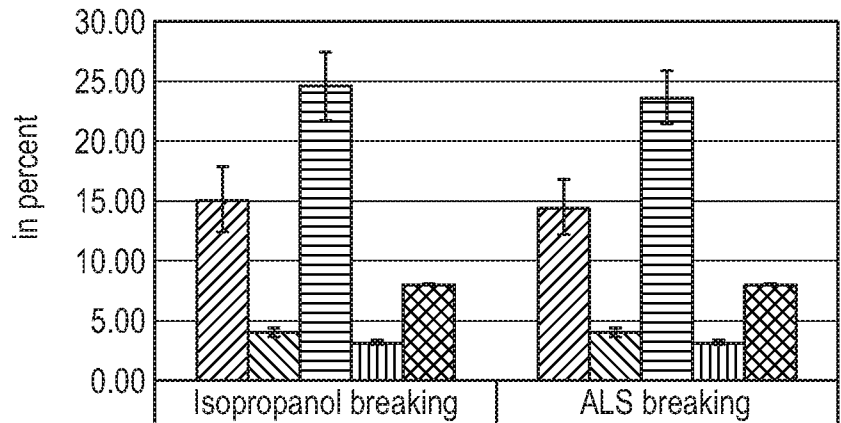


Fig. 2

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A

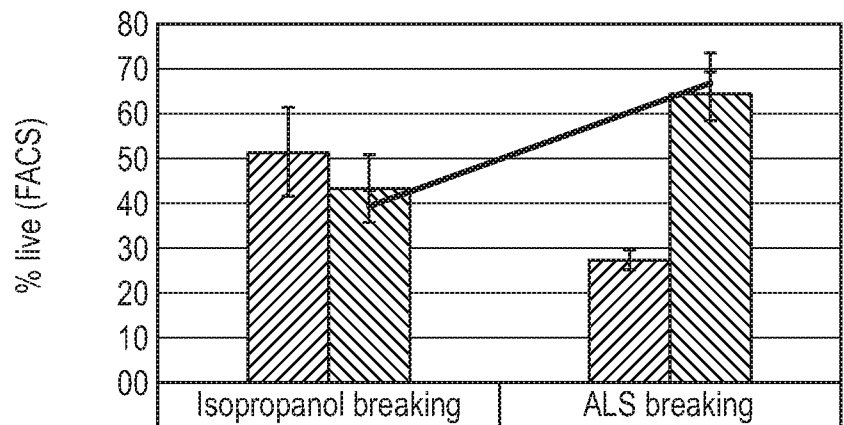
Sequencing Performance



▨ Average of perfect reads (%)	15.11	14.51
▩ Average of error rate (%)	3.98	4.06
▧ Average of perfect reads (%), best file	24.60	23.67
▦ Average of error rate (%), best file	3.14	3.23
▤ Number of replicates	8	8

B

Enrichment



▨ Average of FACS - % live after breaking	51	28
▩ Average of FACS - % live after enrichment	43	65
▧ Number of replicates	8	8
— Average of mapped reads, best tile	24651	41290

Fig. 3

C

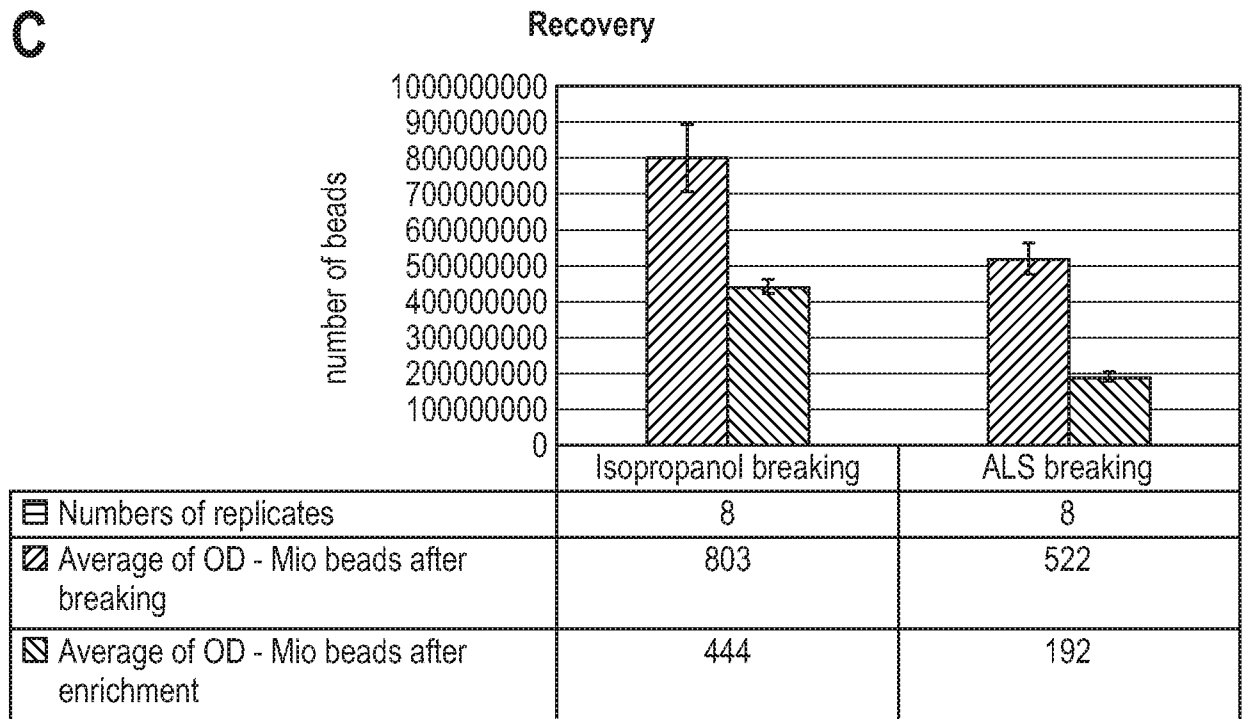


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2017/000097

A. CLASSIFICATION OF SUBJECT MATTER
 INV. C12Q1/68 C12N15/10
 ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C12Q C12N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, CHEM ABS Data, EMBASE, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2010/014920 A1 (UNIV JOHNS HOPKINS [US]; DIEHL FRANK [DE]; DIAZ LUIS [US]; KINZLER KEN) 4 February 2010 (2010-02-04)	1-11, 13-15
Y	abstract page 2, paragraph 8 - page 3 page 42, paragraphs 98,99 -----	12
X	WO 2014/068407 A2 (SYSMEX INOSTICS GMBH [DE]) 8 May 2014 (2014-05-08)	1-11, 13-15
Y	abstract paragraphs [0013], [0041], [0080], [0081]; claims 15,16,22,23,31-33; table 2 -----	12
Y	WO 2015/170187 A2 (QIAGEN GMBH [DE]) 12 November 2015 (2015-11-12)	12
A	abstract page 2, paragraph 1 page 4 -----	1-11, 13-15
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Further documents are listed in the continuation of Box C.

See patent family annex.

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Date of the actual completion of the international search

6 April 2017

Date of mailing of the international search report

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Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
 NL - 2280 HV Rijswijk
 Tel. (+31-70) 340-2040,
 Fax: (+31-70) 340-3016

Authorized officer

Celler, Jakub

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International application No

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