TEMPORARY SLEEVE  12 SWELLABLE PACKER

A packer system ready for downhole use includes an elastomer member, wherein the elastomer member is swellable or inflatable; and a temporary containment enclosing the elastomer member, wherein the temporary containment comprises a degradable material. A method for deploying a swellable packer includes running a packer system into a well to a predetermined location, wherein the packer system comprises a swellable packer or an inflatable packer that is enclosed by a temporary containment, wherein the temporary containment comprises a degradable material; and degrading the degradable material of the temporary containment to set the swellable packer.
TEMPORARY CONTAINMENTS FOR SWELLABLE AND INFLATABLE PACKER ELEMENTS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims, under 35 U.S.C. §119(e), the benefits of U.S. Provisional Patent Application No. 60/870,859 filed on Dec. 20, 2006. This Provisional Application is incorporated by reference in its entirety. This application is related to a co-pending application (Schlumberger Attorney Docket No. 68.0691), entitled “Smart Actuation Materials Triggered by Degradation in Oilfield Environments and Method of Use,” by Marya et al., filed herewith.

FIELD OF INVENTION

[0002] The present invention relates generally to oilfield exploration, production, and testing, and more specifically to swellable and inflatable packer elements.

BACKGROUND

[0003] In a variety of wellbore environments, completion tools such as packers need to be safely and controllably deployed to precise locations to provide basic functions, such as zonal isolation, tubing anchoring, casing protection, and flow control. Packers typically include production packers, zonal isolation packers and gravel pack packers. Most packers are surface controlled and set by mechanical and/or hydraulic mechanisms.

[0004] A type of packers known as inflatable packers uses an inflatable bladder to expand the packer element against the casing or wellbore to provide zone isolation. In preparation for setting the packer, a drop ball or series of tubing movements are generally required, with the hydraulic pressure required to inflate the packer provided by carefully applying surface pump pressure. Inflatable packers are capable of relatively large expansion ratios, an important factor in through-tubing work where the tubing size or completion components can impose a significant size restriction on devices designed to set in the casing or liner below the tubing.

[0005] Another type of packers, known as swellable packers, does not require any mechanical or hydraulic setting mechanisms. These packers include a swellable material, which volume expand upon contacting a selected fluid. The selected fluids may be water-based (including diluted acids and brines) or hydrocarbons. Depending upon the types of fluids and elastomers used, the chemical swelling process may increase the volume of a packer by as much as several hundred percents. In such a swelling process, the swellable packer element typically expands quickly during the initial phase. Then, the swelling continues at a slower rate.

[0006] Due to their simplicity of actuation, swell packers are attractive for zonal isolation applications. Such packers may be used for cased hole and open hole applications. In open hole applications, the use of swellable packers is more challenging and the packer elements are more likely to be damaged.

[0007] If the packer swells too quickly, the packer may not reach its intended downhole destination. Swelling that starts prematurely would make impossible the safe delivery of the packer to the desired location and could result in permanent damages to the sleeve; and evidently improper sealing.

[0008] If, on the contrary, the packer expands too slowly, the swell packer is likely to loose its advantages. A packer that is slow to set would inevitably create rig time waste. Rig times are extremely costly, and deployment and setting of the packers should be conducted within a limited time. The ability to control the settings of such packers is therefore very important for their use.

[0009] Some swellable packer designs simply use an exposed element that begins to swell upon insertion into a wellbore, with the idea that the swelling will progress slowly enough to allow enough time for the delivery of the packer to a desired location downhole. Some examples of such packers are disclosed in: U.S. Pat. Nos. 6,848,505; 4,137,970; 4,919,989; 4,936,386; and 6,854,522.

[0010] In another design of swellable packers, the swellable material is covered by a protective envelope, which is made of high tear resistant elastomers. Examples of such a design are disclosed in: U.S. Pat. Nos. 6,073,692; 6,834,725; 5,084,605; and 5,195,583.

[0011] In yet another design, a swellable packer may be covered with a protective cover that may be removed downhole to allow a predetermined time to deliver the packer to the desired location before the onset of swelling. Examples of swelling packers with a delay feature to facilitate delivery are disclosed: U.S. Pat. Nos. 4,862,967; 6,854,522; 3,918,523; and 4,612,985.

[0012] Another design makes use of a swaging (a retaining device), wherein a swelling member is held by a mechanical retainer during the delivery of the packer to the desired location in the well. Upon reaching the desired location, the expansion of the swellable materials breaks the retainer or otherwise defeats it so that swelling can take place. A packer involving a swaging device is disclosed in U.S. Patent No. 6,854,522.

[0013] Another design uses multilayer packer elements to insulate proper deployment. A typical multilayered packer element includes an elastomeric element covered with another elastomeric material that provides a slow rate of reaction in the packer setting fluid.

[0014] While these prior art packer elements are useful in many downhole operations, there remains a need for improved swellable packer elements.

SUMMARY

[0015] One aspect of the invention relates to swellable packers. A swellable packer in accordance with one embodiment of the invention includes a packer having a swellable material; and a temporary containment enclosing the packer, wherein the temporary containment comprises a degradable material that protects the swellable elastomer of the packer, and prevent premature and undesirable swelling.

[0016] Another aspect of the invention relates to inflatable packers. An inflatable packer in accordance with one embodiment of the invention includes a packer having an inflatable elastomer part; and a temporary containment enclosing the packer, wherein the temporary containment comprises a degradable material that prevents the inflatable packers to accidentally inflate.

[0017] Another aspect of the invention relates to methods for deploying a swellable packer or an inflatable packer in a wellbore. A method in accordance with one embodiment of the invention includes running a packer system into a well to a predetermined location, wherein the packer system comprises a swellable packer or an inflatable packer that is
enclosed by a temporary containment, wherein the temporary containment comprises a degradable material; and degrading the degradable material of the temporary containment to set the packer.

[0018] Other aspects and advantages of the invention will be apparent from the following description and the appended claims.

BRIEF DESCRIPTION OF DRAWINGS

[0019] FIG. 1 shows a schematic illustrating a swellable packer having a temporary containment that is made of a degradable material in accordance with one embodiment of the invention.

[0020] FIGS. 2A and 2B illustrate a swellable packer element before and after deployment in accordance with one embodiment of the invention.

[0021] FIGS. 3A and 3B show a schematic illustrating inflatable packer elements having temporary containments used in zonal isolation with sand screen in accordance with one embodiment of the invention.

[0022] FIGS. 4A and 4B show two charts each illustrating the effect of increases in temperature and pH, respectively on the rate of degradation of a degradable material in accordance with one embodiment of the invention.

DETAILED DESCRIPTION

[0023] In the following description, numerous details are set forth to provide an understanding of the present invention. However, it would be understood by those skilled in the art that the present invention may be practiced without these details and that numerous variations or modifications from the described embodiments may be possible without departing from the scope of the invention.

[0024] Embodiments of the invention relate to temporary containments for swellable and inflatable packers that may be fully degraded downhole once the packers are delivered to its intended location. The materials used to provide a temporary containment for the swellable packers may be metals, alloys, polymers, plastics, ceramics, and composites or combinations of these different materials provided that they may be induced to degrade by a selected reagent or condition. The degradable materials in accordance with embodiments of the invention are selected, and/or specifically designed for their ability to degrade under predetermined conditions; e.g., the existing wellbore environment, or by injection/pumping of an active fluid (i.e. a fluid that would degrade the materials of the temporary containment).

[0025] The “degradation” as used herein refers to any process that converts a degradable material from a first state (or phase) to a second state (or phase). The “degradation” may be in the form of dissolution, disintegration (defragmentation), swelling, or shrinkage. The degradation of the degradable materials may be by contacting selected fluids, or by changing temperatures and/or pressures. In addition, the pH of the fluids may also be changed to influence degradation of the degradable materials, in particular rate of degradation. With changing temperature and/or pressure as the degradation mechanism, the materials may be so selected that the changes in temperatures and/or pressure (i.e., in typical downhole applications) either reduce or increase degradation rates. FIGS. 4A and 4B show two charts illustrating how degradation rates (i.e., the degradation of the degradable materials) may be controlled by temperature (FIG. 4A) and pH (FIG. 4B).

[0026] In accordance with some embodiments of the invention, the degradation may be activated by contacts with selected fluids. The so-called fluids that can be used to degrade the degradable materials of the temporary containment may be solvent to the particular materials such that these materials will dissolve in the fluids. For oil and gas applications, the active fluid may be aqueous or non-aqueous. Examples of degradable materials may include hydrophobic materials that can be dissolved by hydrophobic solvents, or hydrophilic materials that can be dissolved by water.

[0027] Thus, in accordance with embodiments of the invention, a simple example of degradable materials for temporary containment for swellable and inflatable packers may be a hydrophobic material that is not soluble in an aqueous solvent, but is readily soluble in a hydrophobic solvent. Such a hydrophobic material may be used to construct a portion (or all) of a packer element. The presence of the hydrophobic material (temporary containment) keeps the device in an initial state. When actuation of the device is desired, a solvent may be brought into contact with the device. The hydrophobic solvent dissolves the hydrophobic material and removes the temporary containment. As a result, the device adopts a second state. Similarly, a hydrophilic material may be used in a device to be deployed in a non-aqueous environment. When actuation is needed, water or an aqueous solution may be used to dissolve the degradable material.

[0028] In accordance with embodiments of the invention, the degradable materials may be metallic (or alloy), organic (e.g., polymers or composite), inorganic (e.g., waterglass), or ceramic. Examples of polymer degradable materials may include any polymer having a functional group that can be converted into a different type of functional group. After conversion, the physical and/or chemical properties of such polymers are changed. The functional groups that are useful in this regard, for example, may include hydrolyzable functional groups such as anhydrides, lactones, esters, imides, lactams, and the like. Note that the anhydrides, lactones and esters include thioanhydrides, thiolactones and thioesters. A common property of these functional groups is that they can be readily hydrolyzed by a base (e.g., OH⁻) or a nucleophile (e.g., ammonia, a hydroxylamine, or a nucleophilic phosphate: R—NH₃⁺). A base may be any base commonly known in the art, such as sodium hydroxide, potassium hydroxide, lithium hydroxide, or the like. When a base is added to or generated in a solution, the pH of the solution is raised. Thus, adding or generating a base may be referred to as raising the pH of a solution.

[0029] Examples of such polymers may include ISOBAM 600® manufactured by Kuraray Co., Ltd. (Tokyo, Japan). ISOBAM 600® is a co-polymer of isobutylene with maleic anhydride. This polymer is insoluble in water under acidic or neutral conditions. However, the polymer becomes water soluble in the presence of a base or a nucleophile because the anhydride groups can be readily opened up by the base or the nucleophile. Upon hydrolysis this polymer becomes water soluble.

[0030] Other examples may include modified polyvinyl alcohol (PVOH). PVOH is typically prepared by polymerizing vinyl acetate, followed by hydrolysis of the acetate groups. The hydrolysis step can be controlled to occur to a desired extent such that the PVOH has a desired property—not soluble in water. Examples of such modified PVOH poly-
mbers are described in U.S. Pat. No. 5,137,969, issued to Marten et al. (Col. 5, lines 1-11). Some of these modified PVOH are sold by Celanese Chemicals (Dallas, Tex., U.S.A.) under the trade name of Vytex™. Such PVOH can be hydrolyzed by base to become water soluble. Similarly, low-viscosity latex, such as those supplied by Hexion Specialty Chemicals (Columbus, Ohio), may also be prepared to retain some functional groups such that it is not soluble in aqueous medium until such functional groups are hydrolyzed by base. These materials are described in a co-pending application Ser. No. 11/616060, entitled “Fluid Loss Control Agent With Triggerable Removal Mechanism,” by Hloefer et al.  

In addition to adding a base (increased pH) or nucleophile, these degradable polymer materials may also be degraded by increased temperatures. These materials are susceptible to slow hydrolysis in aqueous medium even without added base or nucleophile. The slow background rates may be increased by increasing temperatures. For example, the background hydrolysis rates of these polymers at room temperature may not be noticeable. However, the same reaction may become sufficiently fast to degrade these polymers in downhole conditions.

The degradable materials in accordance with embodiments of the invention are selected for their ability to degrade under predetermined conditions and may comprise, for example, calcium, magnesium, or aluminum, as one constituent of the material. In accordance with some embodiments of the invention, such degradable materials may be metals, alloys, or composites of metals and alloys that may include non-metallic materials such as polymer, plastics, other organic materials (e.g., pasty fluids), or ceramics.

Typical examples of degradable metals and alloys in accordance with embodiments of the invention may include alkaline and alkaline-earth metals such as calcium (Ca safely dissolves in water regardless of pH), magnesium (Mg dissolves at low pH), aluminum (Al dissolves at low pH), and alloys and composites of those metals that degrade at water rates that depend upon temperature, pressure, and fluid composition. For example, acids may accelerate degradation of these metals or alloys.

The following Table lists some examples of metal and alloy degradable materials in accordance with embodiments of the invention. The Table lists metal and alloy compositions, degradation rates at normal pressure (1 atm) in water of specific pH and temperature, as well as their approximate ambient-temperature strength. As shown in this Table, an alloy of calcium containing 20 percent by weight magnesium degrades much slower than pure calcium metal (i.e., 99.99% Ca) and is also about 10 times stronger (i.e., its strength is comparable to that of quenched and tempered steels). In addition, note that aluminum can be made degradable in neutral water with suitable alloying elements.

<table>
<thead>
<tr>
<th>Material</th>
<th>Strength (MPa)</th>
<th>Temperature (°C.)</th>
<th>pH range</th>
<th>Degradation rate (mm/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium metal</td>
<td>~70</td>
<td>25</td>
<td>3-11</td>
<td>~5</td>
</tr>
<tr>
<td>(99.99% Ca)</td>
<td>65</td>
<td>3-11</td>
<td>10-11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>3-11</td>
<td>17-20</td>
<td></td>
</tr>
<tr>
<td>Calcium alloy</td>
<td>~700</td>
<td>25</td>
<td>3-11</td>
<td>~0.05</td>
</tr>
<tr>
<td>(Ca—20 wt. % Mg)</td>
<td>65</td>
<td>3-11</td>
<td>0.2-0.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>3-11</td>
<td>1.2-1.7</td>
<td></td>
</tr>
<tr>
<td>Aluminum metal</td>
<td>~100</td>
<td>90</td>
<td>7</td>
<td>~0.0001</td>
</tr>
<tr>
<td>(99.99% Ca)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Typical examples of degradable ceramics are those made of alkaline and alkaline-earth metals, such as calcium carbonates, calcium phosphate, and calcium sulfate, to name a few. The dissolution behavior of such ceramics will depend on their composition, processing, final form, as well as local pH and pO2.

Embodiments of the invention may be used with any swellable packers known in the art. FIG. 1 shows a swell packer 11, which includes a swellable elastomer 12 on a basepipe or mandrel 13. The swellable elastomer 12 has anti-extrusion rings 14 made of metal on both sides. The swellable elastomer 12 may be bonded to the base pipe 13 on its inner side. The outer surface of the swellable elastomer 12 is protected by a temporary sleeve or temporary containment 15. The temporary containment 15 can be made of a degradable material in accordance with embodiments of the invention, such as degradable polymers and degradable metals/alloys. In accordance with some embodiments of the invention, the temporary containment 15 may be made of inorganic materials, such as water glass (or soluble glass). Water glass is a colorless, transparent, grasslike substance available commercially as a powder or as a transparent, viscous solution in water. Chemically it is sodium silicate, potassium silicate, or a mixture of these. It is prepared by fusing sodium or potassium carbonate with sand or by heating sodium or potassium hydroxide with sand under pressure. Water glass is very soluble in water, but the glassy solid dissolves slowly, even in boiling water.

In accordance with some embodiments of the invention, the temporary containment 15 may be made of polymers or composites that include particles of soluble polymer or metals. That is, the temporary containment 15 need not be entirely made of a degradable material. For instance, it may be a layer that contains both degradable and non-degradable materials. When such temporary containments come in contact with appropriate fluids, the degradable materials will dissolve to leave behind a layer (non-degradable part) with very high porosity and permeability.

In accordance with embodiments of the invention, an inflatable packer is first delivered to the desired location (as shown in FIG. 2A) and then the temporary containment is degraded to allow the packer to inflate and seal the wellbore (as shown in FIG. 2B). FIG. 2A shows an inflatable packer 21 on a basepipe 23 has been delivered to the desired location in a wellbore. In order to prevent damage to the outer elastomer layer of the packer, a temporary containment 25 is provided on the outside of the inflatable packer 21. When the temporary containment 25 comes in contact with an appropriate fluid, it disintegrates and/or dissolves. As a result, the temporary containment 25 loses its mechanical integrity, which in turn allows the inflatable packer 21 to be deployed in an unhindered manner, as shown in FIG. 2B. The advantage of the temporary containment 25 is to protect the delicate elastomer
layer from damages (such as abrasion, wear and gauging), while the inflatable packer 21 is being run in hole. The temporary containment 25 also prevents the elastomer layers from swabbing off. Therefore, the operators can run the packer to the setting depth at a faster rate.

[0039] A swellable packer in accordance with embodiments of the invention may be used in any downhole operations that require a packer. FIGS. 3A and 3B show an example of packers used in sand screening. FIG. 3A shows swell packers 31 with temporarycontainments 35 to control the swelling of the packers 31 that can be used as annular constrictors for use with sand screens 36. The temporary containment 35 can be made of any degradable material in accordance with embodiments of the invention, such as metals, alloys, or polymer that readily reacts with appropriate fluids (e.g., a fluid with high or low pH). In accordance with some embodiments of the invention, the containment 35 can also be made of water soluble materials (for use in a hydrocarbon environment) or hydrocarbon soluble materials (for use in an aqueous environment). In accordance with some embodiments of the invention, the temporary containment 35 may be made to dissolve or disintegrate by spotting acids. Once the temporary containment 35 is degraded, the swellable packers 31 can be inflated by contacting a fluid to seal the wellbore into different zones, as shown in FIG. 3B.

[0040] While the invention has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of the invention as disclosed herein. Accordingly, the scope of the invention should be limited only by the attached claims.

What is claimed is:

1. A packer system for downhole use, comprising:
   an elastomer member, wherein the elastomer member is swellable or inflatable; and
   a temporary containment enclosing the elastomer member, wherein the temporary containment comprises a degradable material.

2. The packer system of claim 1, wherein the degradable material comprises a metal or an alloy.

3. The packer system of claim 2, wherein the metal or alloy is one selected from the group consisting of calcium, aluminum, magnesium, and an alloy thereof.

4. The packer system of claim 1, wherein the degradable material comprises a polymer.

5. The packer system of claim 4, wherein the polymer comprises a functional group that is hydrolysable by a base or a nucleophile.

6. The packer system of claim 1, wherein the degradable material comprises an inorganic material.

7. A method for deploying a packer, comprising:
   running a packer system into a well to a predetermined location, wherein the packer system comprises a swellable packer or an inflatable packer that is enclosed by a temporary containment, wherein the temporary containment comprises a degradable material; and
degrading the degradable material of the temporary containment to set the swellable packer or the inflatable packer.

8. The method of claim 7, wherein the degrading of the temporary containment is by contacting with a fluid.

9. The method of claim 8, wherein the fluid is one selected from the group consisting of water, hydrocarbon, an acid solution, and brine.

10. The method of claim 7, wherein the degrading of the temporary containment is initiated by changing temperature, by changing pressure, or by changing temperature and pressure.

11. The method of claim 7, wherein temporary containment comprises a coating on the degradable material such that degradation is retarded.

12. The method of claim 7, wherein the degradable material is one selected from the following: a metal, and an alloy.

13. The method of claim 7, wherein the degradable material is a polymer.

14. The method of claim 7, wherein the degradable material is an inorganic material.