

Claim Chart for '740 Patent claims 1-81

Claim 1
[1pre] A dissolvable magnesium alloy
[1a] in which additions of high electronegative intermetallic formers are selected from one or more elements with an electronegativity of greater than 1.75 and 0.2-5 wt. % of one or more elements with an electronegativity of 1.25 or less,
[1b] a magnesium content in said dissolvable magnesium alloy is greater than 50 wt. %,
[1c] said one or more elements with an electronegativity of greater than 1.75 form a precipitate, particle, and/or intermetallic phase in said dissolvable magnesium alloy, said one or more elements with an electronegativity of greater than 1.75 include one or more elements selected from the group of tin, nickel, iron, cobalt, silicon, nickel, chromium, copper, bismuth, lead, tin, antimony, indium, silver, aluminum, gold, platinum, cadmium, selenium, arsenic, boron, germanium, carbon, molybdenum, tungsten, manganese, zinc, rhenium and gallium, said one or more elements with an electronegativity of 1.25 or less are selected from the group of calcium, strontium, barium, potassium, neodymium, cerium, sodium, lithium, cesium, yttrium, lanthanum, samarium, europium, gadolinium, terbium, dysprosium, holmium and ytterbium,
[1d] said dissolvable magnesium alloy has a dissolution rate of at least 5 mg/cm ² ·hr. in 3 wt. % KCl water mixture at 90° C.

Claim 2
[2pre] A dissolvable magnesium composite
[2a] that at least partially forms a ball, a frac ball, a tube, a plug or other tool component that is to be used in a well drilling or completion operation,
[2b] said dissolvable magnesium composite includes in situ precipitate,
[2c] said dissolvable magnesium composite comprising a mixture of magnesium or a magnesium alloy and an additive material,
[2d] said magnesium composite includes greater than 50 wt. % magnesium,
[2e] said in situ precipitate includes said additive material, said additive material includes one or more metal materials selected from the group consisting of a) copper wherein said copper constitutes 0.1-35 wt. % of said dissolvable magnesium composite, b) wt. % nickel wherein said nickel constitutes 0.1-23.5 wt. % of said dissolvable magnesium composite, and c) cobalt wherein said cobalt constitutes 0.1-20 wt. % of said dissolvable magnesium composite,
[2f] said dissolvable magnesium composite has a dissolution rate of at least 75 mg/cm ² /hr. in 3 wt. % KCl water mixture at 90° C.
Claim 3
[3] The dissolvable magnesium composite as defined in claim 2, wherein said dissolvable magnesium composite has a dissolution rate of 75-325 mg/cm ² /hr. in 3 wt. % KCl water mixture at 90° C.

Claim 4
[4] The dissolvable magnesium composite as defined in claim 2, wherein said dissolvable magnesium composite has a dissolution rate of 84-325 mg/cm ² /hr. in 3 wt. % KCl water mixture at 90° C.
Claim 5
[5] The dissolvable magnesium composite as defined in claim 2, wherein said dissolvable magnesium composite has a dissolution rate of 100-325 mg/cm ² /hr. in 3 wt. % KCl water mixture at 90° C.
Claim 6
[6] The dissolvable magnesium composite as defined in claim 2, wherein said dissolvable magnesium composite has a dissolution rate of 0.6-1 mg/cm ² /hr. in 3 wt. % KCl water mixture at 21° C.
Claim 7
[7] The dissolvable magnesium composite as defined in claim 2, wherein said dissolvable magnesium composite has a dissolution rate of 0.5-1 mg/cm ² /hr. in 3 wt. % KCl water mixture at 20° C.
Claim 8
[8]The dissolvable magnesium composite as defined in claim 2, wherein said magnesium alloy comprises greater than 50 wt. % magnesium and no more than 10 wt. % aluminum, and one or more metals selected from the group consisting of 0.5-10 wt. % aluminum, 0.1-2 wt. % zinc, 0.01-1 wt. % zirconium, and 0.15-2

wt. % manganese.

Claim 9

[9] The dissolvable magnesium composite as defined in claim 2, wherein said magnesium alloy comprises greater than 50 wt. % magnesium and no more than 10 wt. % aluminum, and one or more metals selected from the group consisting of 0.1-3 wt. % zinc, 0.05-1 wt. % zirconium, 0.05-0.25 wt. % manganese, 0.0002-0.04 wt. % boron, and 0.4-0.7 wt. % bismuth.

Claim 10

[10] The dissolvable magnesium composite as defined in claim 2, wherein said additive material includes nickel.

Claim 11

[11] The dissolvable magnesium composite as defined in claim 2, wherein said additive material includes nickel, said nickel constitutes 0.3-7 wt. % of said dissolvable magnesium composite.

Claim 12

[12] The dissolvable magnesium composite as defined in claim 2, wherein said additive material includes nickel, said nickel constitutes 7-10 wt. % of said dissolvable magnesium composite.

Claim 13

[13] The dissolvable magnesium composite as defined in claim 2, wherein

said additive material includes copper.

Claim 14

[14] The dissolvable magnesium composite as defined in claim 2, wherein said additive material includes copper, said copper constitutes 0.5-15 wt. % of said dissolvable magnesium composite.

Claim 15

[15] The dissolvable magnesium composite as defined in claim 2, wherein said additive material includes copper, said copper constitutes 15-35 wt. % of said dissolvable magnesium composite.

Claim 16

[16] The dissolvable magnesium composite as defined in claim 2, wherein said magnesium content in said dissolvable magnesium composite is at least 75 wt. %.

Claim 17

[17] The dissolvable magnesium composite as defined in claim 2, wherein said magnesium content in said dissolvable magnesium composite is at least 85 wt. %.

Claim 18

[18] The dissolvable magnesium composite as defined in claim 2, wherein said additive material is a metal or metal alloy.

Claim 19
[19pre] A dissolvable magnesium cast composite
[19a] comprising a mixture of magnesium or a magnesium alloy and an additive material,
[19b] said additive material includes one or more metals selected from the group consisting of a) copper wherein said copper constitutes at least 0.01 wt. % of said dissolvable magnesium cast composite, b) nickel wherein said nickel constitutes at least 0.01 wt. % of said dissolvable magnesium cast composite, and c) cobalt wherein said cobalt constitutes at least 0.01 wt. % of said dissolvable magnesium cast composite,
[19c] said magnesium composite includes in situ precipitate, said in situ precipitate includes said additive material,
[19d] a plurality of particles of said in situ precipitate having a size of no more than 50 μm ,
[19e] said magnesium composite has a dissolution rate of at least 5 $\text{mg}/\text{cm}^2/\text{hr}$. in 3 wt. % KCl water mixture at 90° C.
Claim 20
[20] The dissolvable magnesium cast composite as defined in claim 19, wherein said magnesium composite includes at least 85 wt. % magnesium.
Claim 21-22
[21-22] The dissolvable magnesium cast composite as defined in claim 19

and 20, wherein said magnesium composite has a dissolution rate of at least 40 mg/cm²/hr. in 3 wt. % KCl water mixture at 90° C.

Claim 23-26

[23-26] The dissolvable magnesium cast composite as defined in claim 19 or 20 or 21 or 22, wherein said magnesium composite includes no more than 10 wt. % aluminum.

Claims 27-28

[27-28] The dissolvable magnesium cast composite as defined in claim 23 or 25, wherein said magnesium composite includes at least 50 wt. % magnesium.

Claims 29-34

[29-34] The dissolvable magnesium cast composite as defined in claim 19 or 20 or 22 or 23 or 27 or 28, wherein said dissolvable magnesium cast composite has a dissolution rate of 40-325 mg/cm²/hr. in 3 wt. % KCl water mixture at 90° C.

Claims 35-36

[35-36] The dissolvable magnesium cast composite as defined in claim 27 or 28, wherein said magnesium alloy includes over 50 wt. % magnesium and one or more metals selected from the group consisting of aluminum, boron, bismuth, zinc, zirconium, and manganese.

Claims 37-38

[37-38] The dissolvable magnesium cast composite as defined in claim 27 or 28, wherein said magnesium alloy includes over 50 wt. % magnesium and one or more metals selected from the group consisting of aluminum in an amount of 0.5-10 wt. %, zinc in an amount of 0.1-6 wt. %, zirconium in an amount of 0.01-3 wt. %, manganese in an amount of 0.15-2 wt. %, boron in an amount of 0.0002-0.04 wt. %, and bismuth in an amount of 0.4-0.7 wt. %.

Claims 39-40

[39-40] The dissolvable magnesium cast composite as defined in claim 27, wherein said magnesium alloy includes over 50 wt. % magnesium and one or more metals selected from the group consisting of aluminum in an amount of 0.5-10 wt. %, zinc in an amount of 0.1-3 wt. %, zirconium in an amount of 0.01-1 wt. %, manganese in an amount of 0.15-2 wt. %, boron in an amount of 0.0002-0.04 wt. %, and bismuth in amount of 0.4-0.7 wt. %.

Claim 41-45

[41-45] The dissolvable magnesium cast composite as defined in claim 20 or 22 or 23 or 27 or 28, wherein said magnesium alloy includes at least 85 wt. % magnesium and one or more metals selected from the group consisting of 0.5-10 wt. % aluminum, 0.05-6 wt. % zinc, 0.01-3 wt. % zirconium, and 0.15-2 wt. % manganese.

Claims 46-47

[46-47] The dissolvable magnesium cast composite as defined in claim 27 or

28, wherein said magnesium alloy comprises greater than 50 wt. % magnesium and one or more metals selected from the group consisting of 0.1-3 wt. % zinc, 0.05-1 wt. % zirconium, 0.05-0.25 wt. % manganese, 0.0002-0.04 wt. % boron, and 0.4-0.7 wt. % bismuth.

Claim 48

[48] The dissolvable magnesium cast composite as defined in claim 19, wherein said magnesium alloy comprises 60-95 wt. % magnesium, 0.5-10 wt. % aluminum, 0.05-6 wt. % zinc, and 0.15-2 wt. % manganese.

Claims 49

[49] The dissolvable magnesium cast composite as defined in claim 19, wherein said magnesium alloy includes 60-95 wt. % magnesium and 0.01-1 wt. % zirconium.

Claim 50

[50] The dissolvable magnesium cast composite as defined in claim 19, wherein said magnesium alloy includes 60-95 wt. % magnesium, 0.05-6 wt. % zinc, and 0.01-1 wt. % zirconium.

Claim 51

[51] The dissolvable magnesium cast composite as defined in claim 19, wherein said magnesium alloy includes over 50 wt. % magnesium and one or more metals selected from the group consisting of 0.1-3 wt. % zinc, 0.01-1 wt. % zirconium, 0.05-1 wt. % manganese, 0.0002-0.04 wt. % boron, and 0.4-0.7 wt. %

bismuth.

Claims 52-57

[52-57] The dissolvable magnesium cast composite as defined in claim 19 or 20 or 22 or 23 or 27 or 28, wherein said additive material includes nickel, said nickel constitutes 0.1-23.5 wt. % of said dissolvable magnesium cast composite.

Claims 58-63

[58-63] The dissolvable magnesium cast composite as defined in claim 19 20, 22, 23, 17, or 28, wherein said additive material includes copper, said copper constitutes 0.01-35 wt. % of said dissolvable magnesium cast composite.

Claims 64-69

[64-69] The dissolvable magnesium cast composite as defined in claim 19 or 20 or 22 or 23 or 27 or 28, wherein said additive material includes copper, said copper constitutes 0.5-15 wt. % of said dissolvable magnesium cast composite.

Claims 70-75

[70-75] The dissolvable magnesium cast composite as defined in claim 19 or 20 or 22 or 23 or 27 or 28, wherein said additive material includes cobalt, said cobalt constitutes 0.1-20 wt. % of said magnesium composite.

Claims 76-81

[76-81] The dissolvable magnesium cast composite as defined in claim 19, 29, 22, 23, 27 or 28, wherein said additive material includes one or more metal materials selected from the group consisting of 0.1-35 wt. % copper, 0.1-24.5

wt. % nickel and 0.1-20 wt. % cobalt.