(such as the composition of the chemical conversion film and drying temperature) and various quality properties. As a result, the present inventors have found it important to form an insoluble complex film with small residual amount of a soluble salt and a solvent, for the enhancement of corrosion resistance. That is, it has been found that, when excessive amounts of a fluoride, an organic acid, and an amine with a high-boiling point remain in the chemical conversion film, corrosion resistance is remarkably lowered. Particularly, it has been found that, the composition of the chemical treatment solution is quite important, because when the chemical treatment solution is dried at a low temperature and for a short period of time, a complex salt is less likely to be formed, and a fluoride, an organic acid, and an amine with a high-boiling point tend to remain.

[0013] As a result of intensive study in consideration of those respects, the present inventors have found that the above-described problems can be solved by forming a chemical conversion film using a chemical treatment solution containing a water-soluble molybdate, a vanadium salt, an amine having a low boiling point, a group 4A metal oxoate and a phosphate, and have studied further to complete the present invention.

[0014] That is, the present invention relates to the following chemical treatment solution:

[1] A chemical treatment solution for coating a zinc-based plated steel sheet having a zinc-based plating layer containing 0.1 to 22.0 mass % of aluminum, the chemical treatment solution containing a water-soluble molybdate, an oxoanion of vanadium having a valence of 5, an amine or ammonia, a hydracid salt, an ammonium salt, an alkaline metal salt or an alkaline earth metal salt of Group 4 element and a phosphate compound, in which a molar ratio of molybdenum to vanadium in the chemical treatment solution is 0.4 to 5.5, a molar ratio of the amine or ammonia to the vanadium in the chemical treatment solution is 0.3 or more, a content of a hydrophilic resin in the chemical treatment solution is at most 100 mass % based on a total amount of the vanadium and the molybdenum in the chemical treatment solution, a total content of

fluorine derived from a fluorine ion or a fluorometal ion in the chemical treatment solution is at most 30 mass % based on the total amount of the vanadium and the molybdenum

in the chemical treatment solution, and a content of silicon derived from a silanol group in the chemical treatment solution is at most 50 mass % based on the total amount of the vanadium and the molybdenum in the chemical treatment solution.

[2] The chemical treatment solution according to [1], in which the amine has a molecular weight of 80 or less.

[0015] Further, the present invention relates to the following chemically treated steel sheet:

[3] A chemically treated steel sheet formed by applying the chemical treatment solution according to [1] and [2] to the surface of a zinc-based plated steel sheet and drying the same, comprising a zinc-based plated steel sheet having a zinc-based plating layer containing 0.1 to 22.0 mass % of aluminum, and a chemical conversion film disposed on the zinc-based plating layer, in which the chemical conversion film includes a first chemical conversion layer disposed on a surface of the zinc-based plating layer and containing vanadium, molybdenum and phosphorus, and a second chemical conversion layer disposed on the first chemical conversion layer and containing a hydracid salt, an ammonium salt, an alkaline metal salt or an alkaline earth metal salt of group 4 element, and a percentage of pentavalent vanadium based on mixed-valent vanadium in the chemical conversion film is 0.7 or more.

[4] The chemically treated steel sheet according to [3], in which the group 4A metal oxoate is a zirconium oxoate, and the chemical conversion film contains 1 to 60 parts by mass of molybdenum, 2 to 20 parts by mass of vanadium, and 10 to 50 parts by mass of phosphorus, based on 100 parts by mass of zirconium.

[5] The chemically treated steel sheet according to [3] or [4], in which the zinc-based plated steel sheet is a hot-dip aluminum- and magnesium-containing zinc plated steel sheet having a hot-dip aluminum- and magnesium-containing zinc plating layer containing 0.1 to 22.0 mass % of aluminum and 1.5 to 10.0 mass % of magnesium.

Advantageous Effects of Invention

CLAIMS

1. A chemical treatment solution for coating a zinc-based plated steel sheet having a zinc-based plating layer containing 0.1 to 22.0 mass % of aluminum, the chemical treatment solution comprising:

a water-soluble molybdate;

an oxoanion of vanadium having a valence of 5;

an amine or ammonia;

a hydracid salt, an ammonium salt, an alkaline metal salt or an alkaline earth metal salt of group 4 element; and

a phosphate compound,

wherein:

a molar ratio of molybdenum to vanadium in the chemical treatment solution is 0.4 to 5.5,

a molar ratio of the amine or ammonia to the vanadium in the chemical treatment solution is 0.3 or more,

a content of a hydrophilic resin in the chemical treatment solution is at most 100 mass % based on a total amount of the vanadium and the molybdenum in the chemical treatment solution,

a total content of fluorine derived from a fluorine ion or a fluorometal ion in the chemical treatment solution is at most 30 mass % based on the total amount of the vanadium and the molybdenum in the chemical treatment solution, and

a content of silicon derived from a silanol group in the chemical treatment solution is at most 50 mass % based on the total amount of the vanadium and the molybdenum in the chemical treatment solution.

2. The chemical treatment solution according to claim 1, wherein the amine has a molecular weight of 80 or less.

3. A chemically treated steel sheet formed by applying the chemical treatment solution according to claim 1 and 2 to the surface of a zinc-based plated steel sheet and drying the same, comprising:

a zinc-based plated steel sheet having a zinc-based plating layer containing 0.1 to 22.0 mass % of aluminum, and a chemical conversion film disposed on the zinc-based plating layer,

wherein:

the chemical conversion film includes a first chemical conversion layer disposed on a surface of the zinc-based plating layer and containing vanadium, molybdenum and phosphorus, and a second chemical conversion layer disposed on the first chemical conversion layer and containing a hydracid salt, an ammonium salt, an alkaline metal salt or an alkaline earth metal salt of group 4 element, and

a percentage of pentavalent vanadium based on mixed-valent vanadium in the chemical conversion film is 0.7 or more.

4. The chemically treated steel sheet according to claim 3, wherein:

the group 4 element is zirconium, and

the chemical conversion film contains 1 to 60 parts by mass of molybdenum, 2 to 20 parts by mass of vanadium, and 10 to 50 parts by mass of phosphorus, based on 100 parts by mass of zirconium.

5. The chemically treated steel sheet according to claim 3 or 4, wherein the zinc-based plated steel sheet is a hot-dip aluminum- and magnesium-containing zinc plated steel sheet having a hot-dip aluminum- and magnesium-containing zinc plating layer containing 0.1 to 22.0 mass % of aluminum and 1.5 to 10.0 mass % of magnesium.