necessary to dry a chemical treatment solution applied to the surface of the steel sheet sufficiently to form an insoluble film. When the drying temperature is low and drying is insufficient, corrosion resistance is remarkably lowered. Therefore, when the chemically treated steel sheet is produced in a continuous line, it is necessary to dry the chemical treatment solution at a high temperature of a steel sheet temperature of about 50 to 200°C, from the viewpoint of both achieving sufficient drying and productivity.

[0009] Recently, $CO_2$ elimination as a countermeasure for global warming and power saving as a countermeasure for power shortage have been required. In particular, in order to cope with Scope 3, products have been required, which contribute to $CO_2$ elimination even in the stage in which raw materials for the products are produced. Accordingly, also in the chromium-free chemical treatment, it has been required to lower the drying temperature and reduce the drying time.

[0010] The present disclosure has been achieved in light of the above-mentioned respects, and an object of the present disclosure is to provide a chemically treated steel sheet which is excellent in corrosion resistance and blackening resistance obtained by employing a zinc-based plated steel sheet as an original sheet, and which is capable of being produced even when an applied chemical treatment solution is dried at a low temperature and for a short period of time.

[0011] Another object of the present disclosure is to provide a chemical treatment solution capable of forming a chemical conversion film that enhances corrosion resistance and blackening resistance even when being dried at a low temperature and for a short period of time.

[0011a] In one aspect of the present disclosure, there is provided a chemically treated steel sheet, formed by applying a chemical treatment solution to the surface of a zinc plated steel sheet and drying the same, wherein the chemical treatment solution comprises:

a molybdenum acid ion;

a pentavalent vanadium ion;

an amine;

an oxoate of group 4 element; and

a compound selected from the group consisting of a diammonium hydrogen phosphate, an ammonium dihydrogen phosphate, and triammonium phosphate,

wherein:

the amine has a molecular weight of 80 or less;

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

a molar ratio of the amine 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;

the 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;

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 an oxoate 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.

Solution to Problem

[0012] The present inventors have studied the chromium-free chemical treatment for the zinc-based plated steel sheet in terms of the relationship between treatment conditions

## CLAIMS

1. A chemically treated steel sheet, formed by applying a chemical treatment solution to the surface of a zinc-based plated steel sheet and drying the same, wherein the chemical treatment solution comprises:

a molybdenum acid ion;

a pentavalent vanadium ion;

an amine;

an oxoate of group 4 element; and

a compound selected from the group consisting of a diammonium hydrogen phosphate, an ammonium dihydrogen phosphate, and triammonium phosphate;

wherein:

the amine has a molecular weight of 80 or less;

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

a molar ratio of the amine 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;

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;

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

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 an oxoate 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.

2. The chemically treated steel sheet according to claim 1, wherein:

the oxoate of group 4 element 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.

3. The chemically treated steel sheet according to claim 1 or 2, 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.