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RESEARCH STATUS OF ROAD DEICING SALT

Guo Mingjun *postgraduate,*
Vinnytsia National Technical University
***Kovalskiy* V.P.** *Ph.D.,*
Vinnytsia National Technical University

Background information

The rapid development of highway construction has greatly improved socio-economic growth and people's living standards, and the safe and efficient operation of highway transportation network is the basis for ensuring the sustained growth of economy. Snow and ice on the road reduce the adhesion coefficient of vehicle tires to the road, according to relevant data, the adhesion coefficient of road surfaces with soft snow is 0.20-0.40, and the adhesion coefficient of road surfaces with compacted snow is 0.15-0.5, the adhesion coefficient of icy roads is only 1/8-1/4 of that of dry roads[1]. Reduced adhesion of road makes the driving stability and braking of the vehicle worse, especially, when the "black ice" phenomenon is formed on the asphalt road, it is difficult for the driver to detect in time, which seriously affects the safety of vehicles and leads to a lot of traffic accident. Preventing snow and icing on roads, removing snow and ice quickly, reducing the incidence of road traffic accidents, and improving the capacity and safety of roads in snow and ice weather have become the primary work of road maintenance departments in winter.

Presentation of the material

In the 1930s, the United States began to use rock salt (mainly composed of sodium chloride) to remove snow from roads. Subsequently, various countries successively adopted chloride salts for snow melting and deicing on roads[2]. In early Japan, sun salt (mainly sodium chloride) was used as the icing salt, in the late 1990s, calcium chloride was partially used[3]. The chlorine salts with the ability to remove snow and ice in various countries mainly include sodium

chloride (NaCl), calcium chloride ($CaCl_2$), magnesium chloride ($MaCl_2$) and potassium chloride (KCl), etc. At first, such salts that can reduce the freezing point of snow and ice are called " deicing salt". So far, chloride-based deicing salts have still occupied a dominant position in road deicing fields, and their usage amounts to more than 90%, especially sodium chloride and calcium chloride are the most widely used[4]. Initially, when using salt to melt snow and ice on roads, transportation departments usually sprayed a single component of solid chloride salt on roads. As people continue to understand the chloride deicing salts, and pay more attention to economy, operability and environmental protection safety, researchers from various countries have begun to develop compound deicing salt.

The research and development of the new road deicing salt is basically carried out in two aspects. First, in order to ensure the efficient snow melting and deicing ability of the deicing salt, the optimization and improvement of the deicing salt is carried out with the low-cost chlorine salt material as the main component. Secondly, for the sake of environmental protection and safety, we seek for non-chlorine deicing salt with the ability to melt snow and ice, and strive to develop the deicing salt that are non-corrosive to transportation facilities and environmentally friendly. Robert A Hartley added carbohydrates and phosphates to the chloride salt to prepare a low-corrosion snowmelt[5]. Japanese researchers have improved calcium chloride deicing salt, the main components are calcium chloride, magnesium sulfate, magnesium chloride, phosphate, and soluble potassium. Based on chlorine salts, Zhang Jingya developed kcl-mgcl2-lux series deicing salt. Among them, Lux is a compound with low melting point and high permeability composed of urea, calcium ammonium nitrate, magnesium ammonium nitrate and hydrophilic surfactants[6]. The addition of Lux has certain fertilizer effect on plants, which makes up for the harm of chloride ions and thus reduces environmental pollution. Wang Xiaoguang took chloride salts such as calcium chloride, magnesium chloride

and potassium chloride as the main components, compounded corrosion inhibitors, phosphate, sodium gluconate, zinc sulfate, thiourea, sodium silicate, sodium molybdate and sodium tungstate, to prepare PSA series deicing salt, which has a fast melting rate and a certain degree of corrosion prevention[7].

The improved technology of deicing salt based on chlorine salt has improved the efficiency of snow melting, and has reduced the corrosion of steel bars and the destruction of plants around the road to different degrees, however, the harm of chloride ion (Cl-) still cannot be effectively dealt with. In order to eliminate the harm of chloride ions in the chloride salt, in the 1980s, the American DOT company first developed the non-chlorine deicing salt, calcium magnesium acetate (CMA), its raw materials used were derived from cellulose wastes and limestone containing magnesium carbonate, CMA reduced the impact on the environment, but failed to be widely used due to high production[8]. Zhang Liangquan prepared CMA by direct reaction of glacial acetic acid and dolomite (Ca/MgO), and studied the influence of production process parameters on deicing salt, and proposed the appropriate process parameters and applicable environment (above -5°C) of CMA[9].

With the continuous research of CMA, it is realized that CMA is usually produced by the reaction of dolomite (Ca/MgO) or limestone (Ca/$MgCO_3$) with glacial acetic acid. Therefore, more researchers turn their research direction to the exploration of low-cost raw materials and simple production processes from the perspective of cost saving and resource saving. Xu Yingmei made low-cost CMA by reacting acetic acid waste liquid (wood vinegar solution) and dolomite powder, its preparation process is simple and effective, and biomass waste is effectively used[10]. The produced CMA has less corrosion to metals and low damage to plants, its ice melting capacity reaches 91% of sodium chloride. On the basis of designing a method for treating furfural wastewater, Kou Yanqiu proposed a process for preparing CMA from acetic acid in furfural wastewater, and the effective component of the recovered CMA was determined to be above

80%[11]. Zhang Jugong discussed the technological conditions for preparing calcium acetate deicing salt using carbide slag as raw material [12].

The environmental protection characteristics of calcium and magnesium acetate have caused people's attention. Related studies have shown that the migration and ion exchange of acetate ions in the soil can precipitate trace metals, acetate ions can be decomposed into H_2CO_3 under the condition of water, and H_2CO_3 forms zinc carbonate and lead carbonate with zinc and lead in the soil, as a result, the concentrations of Cd, Cu, Zn, V, and Cr in water are reduced by the co-precipitation of calcite. Since the acetate ion can degrade in the environment, researchers have carried out a lot of research on acetic acid deicing salt. Luan Guoyan prepared low cost, environmentally friendly deicing salt using acetic acid waste liquid and straw ash as raw materials, on the basis of CMA, potassium acetate was introduced as a snow melting material[13-15].

Conclusion

The research and development of road deicing salt is mainly based on chloride salts. Chloride-based deicing salts are rich in resources, low in cost, and effective in melting snow, but with many disadvantages. In the process of improving chloride salt deicing salt, a large amount of research has only added corrosion inhibitors and plant promoters, which has alleviated the damage of deicing salt to road transportation facilities and surrounding ecology, but the toxicity caused by the continuous accumulation of chloride ions can not be effectively solved. Organic-based deicing salt mainly use acetic acids to remove ice and snow from roads. They are widely used due to their low freezing point, easy degradation, and low corrosion, but their cost is high. There are more studies on CMA deicing salt, and less exploration on the snow melting properties of other acetic acid substances. With the increasing emphasis on environmental protection, it is particularly important to develop a highly efficient, pollution-free, and low-cost environmentally-friendly road deicing salt based on acetic acid to replace the commonly used chlorine salt deicing salt.

Literature

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