Technical Brief

Chloride and acetate-based salts are widely employed by various state DoTs for performing the deicing operation during the winter season. While the chloride-based salts are inexpensive, they can be detrimental to concrete pavements, steel bridges, vehicles, soil quality, and aquatic life. On the other hand, the acetate-based salts are expensive and detrimental to galvanized steels. To circumvent the limitations of chloride and acetate-based salts, alternative deicers, including agro-based byproducts/products have been explored in the recent past. Agro-based byproducts/products include sugar beet, corn steep water, brewing byproducts, succinate salts, etc. Although agro-based deicers exhibited promising results such as reduced freezing point depression, enhanced ice melting, and corrosion inhibition, etc., scaling up their production is challenging as the yield of these agro-based products is far less than the demand. One viable alternative would be to extract the deicers from the most abundantly grown crops in the United States. Since corn is the most planted crop in the United States, the current study focuses on developing corn-based deicers that possess lower freezing point depression, enhanced ice melting capacity, and corrosion inhibition effect.

The PI hypothesizes that the sugar available in the raw corn and the sugar alcohols (polyols) produced from the corn starch play the role of a deicer. Corn juice from fresh corn kernels is first extracted in this study, and the amount of soluble sugar in it is measured. Various blends of deicers referred to as corn-based deicers are then generated by combining corn juice, corn-derived polyols, and salt-brine in different weight fractions. Three polyols, namely sorbitol, maltitol, and mannitol, are extensively studied for their deicing properties. The potential of various blends of corn-based deicers is then examined experimentally by performing five tests, namely, freezing point depression, corrosion inhibition, ice melting capacity, skid resistance, viscosity and, dissolved oxygen. The blends that exhibited the lowest freezing point depression, highest corrosion inhibition capacity, rapid ice melting capability, highest skid resistance, and lowest dissolved oxygen consumed are identified.

The experimental results from the freezing point depression test suggest that the addition of corn juice and corn-based polyols to the standard brine solution enhances the freezing point depression of the water. Among the three polyols, sorbitol and maltitol were observed to achieve the lowest freezing point depressions of -38.1°C and -35.6°C, respectively. Results from accelerated corrosion tests and polarization tests indicated that the corrosion damage was suppressed when a blend of corn-derived polyol and salt-brine was used. Approximately 92% of corrosion inhibition efficiency was achieved for the blend, including maltitol, when compared to traditional salt-brine deicer alone. Ice melting tests revealed that a blend of corn-derived polyols and the salt-brine exhibited superior ice melting capacity even at sub-freezing temperatures when compared to salt brine deicer alone. An increase in ice melting capacity was observed for mannitol when the ambient temperatures were in the range of -20°C to -30°C. Application of corn-derived polyol and salt-brine to the Portland Cement Concrete (PCC) surface led to an average reduction of 33% in the skid resistance when compared to the skid resistance of the dry surface (17% reduction noticed for salt brine). Dissolved oxygen tests on various blends of corn-derived polyol and the salt-brine deicer revealed that the depletion of oxygen in the stream water did not exceed the recommended limit (Apha 1992). Among the three polyols, mannitol was observed to record the least depletion of oxygen from the stream water.

Implementation

Based on the results obtained, a blend of deicer prepared from 27 wt. % Sorbitol+23.3 wt. % salt-brine is recommended for freezing point depressions up to -38.1°C and, 27 wt. % Maltitol+23.3 wt. % salt-brine is recommended for freezing point depressions between -25°C to -35.6°C. In corrosion-prone zones such as steel bridges and the pavements nearby water bodies, a blend of deicer prepared from 0.5-2 wt. % Mannitol+23.3 wt. % salt-brine is recommended. For better ice melting capacity, a blend of deicer prepared from 27 wt. % Mannitol+23.3 wt. % salt-brine is recommended at sub-freezing temperatures of -10°C and -20°C.