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ChemBioPower

Fuels of the Future, Today

Bio-Formate Ice Removal

August 24, 2018: The Latest Fuel Insight from ChemBioPower for Our Stakeholders
Antonio Anselmo

Bridge Collapse: Dateline Genoa Italy August 14, 2018

The Morandi Genoa bridge was finished in the 1967 and was managed by Autostrade per l'Italia SpA. When the bridge collapsed in mid August, cars fell from an average height of 150 feet onto the railway tracks and buildings below, killing 43 people. A 1979 report written by bridge engineer Riccardo Morandi has emerged. The 1979 report noted that salty ocean air and nearby factory pollution led to a "well-known loss of superficial chemical resistance of the concrete," and that "the bridge would need constant upkeep to get rid of rust and other vulnerabilities".

Salt in the Wound: Destruction of Our Infrastructure

Clearing away ice on roadways, bridges and runways is a universal problem throughout North America and Europe. Salting roads began in the U.S. mid-West when rock salt was found under Detroit in 1895. Because of this local resource, Detroit was the first city in the world to apply salt to its roads in 1940. In 2013, U.S. officials applied about 16 million tonnes of salt to roads during the winter season. Over the past 75 years, salt has been used as a de-icer because it is available across the continent and is relatively inexpensive, selling for $55 to $110 per tonne.

Although chloride salts have a low purchase costs, they comes with very high hidden costs. Michigan uses about 2 million tonnes of road salt yearly. The U.S. EPA estimates that every ton of road salt causes approximately $825 in damage to concrete, bridges and vehicles. Michigan's 2 million tonnes, purchased at $110 Million, creates $1,500 Million in damages **annually**.

According to a report by The American Society of Civil Engineers, the cost of repairs for existing infrastructure (mainly bridges) within the United States is estimated at $4,500 Billion in damage by 2025. The Mackinac Center for Public Policy estimated infrastructure damage in Canada at $681 CDN per tonne (469 USD/ton). Canada uses at least 7 million tonnes per year (Environment Canada. 2009). Using the Mackinac Center estimate, that's 4.77 Billion CDN annually of infrastructure damage throughout the dominion. Salt was a key contributor to the deadly 2006 collapse of the De La Concorde Bridge in Laval, PQ that killed six drivers.

How the Salt Gremlins Destroy Bridges

Chloride (Cl from NaCl or CaCl2) is the main cause of bridge concrete deterioration. As chlorides diffuse into the concrete, some chlorides are trapped in a "bound" form, while the rest

of the "free" chlorides diffuse further into the concrete. Free chlorides cause corrosion when they reach the carbon steel rebar, according to the following steps:

- Diffusion of the corrosive ions (usually chloride) into the concrete
- Once chloride ions reaches the carbon steel rebar, corrosion begins
- Corrosion products, which occupy a greater volume than steel, exert an outwards pressure
- Outward pressure cracks the concrete, opening up for easy access to more chlorides
- Concrete covering begins falling away, exposing the rebar to more corrosion

If unattended, the corrosion continues until the rebar cannot bear the longitudinal tensile stresses and the structure collapses. Several tons of salt on the road will clear ice and snow for a day or two. If it snows again in a week, more tons of salt are spread. Again, the benefit lasts a day or so. With repeated salting, nearby bodies of water are also damaged, harming both the stream and the bridge. Short-term benefits are exchanged for long-term damage when using standard road salt.

There Are Better Ways to Remove Ice

Using our processing technology, ChemBioPower Ltd, will be constructing a biomass to renewable chemicals plant in Southern Alberta in 2019. One of the main chemicals produced will be Formic Acid. Formic Acid has many applications. Uses include fuel cell hydrogen carrier, fermentation promoter, silage preservative, leather tanning, drilling mud, gas well stimulation and the base for safe commercial de-icers. The market value of the formic acid market (2017) was estimated to reach $619 Million by 2019 (850,000 tonnes per year), growing at a CAGR of 4.9%, from 2017 to 2022.

Containing the salts of formic acid, sodium formate and potassium formate, these new de-icers will perform as well as the best sodium acetate de-icers that are available on the market today. Formates break-up harmlessly in the environment, much quicker than sodium salts or acetates. Formates also have significantly less impact on water run-off from ice melt.

For example, winters in lower British Columbia have required increasing amounts of ice-melt over past years. During the winter of 2016, Vancouver saw two large snowstorms that caused an ice melt shortage at every Canadian Tire store in the region. Vancouver has also had a difficult time melting road ice in order to free up public transportation systems that primarily use buses. Given the water risk in the area, potassium formate is ideal for this type of city.

The Best Choice: Potassium Formate Renewable De-Icer's:

ChemBioPower intends to provide a better, renewable alternative to road salt, with a choice of new de-icing products. Canada and the United States have a real need for chlorine salt alternatives. Potassium formate is a simple salt of formic acid. It is stabilized as a white solid crystal and can be stored the same as acetate de-icers. For example, 40% potassium formate solution will remove ice at -40 C below (Table 1). In most major northern cities, only a10% solution will be all you ever need in Vancouver or Toronto.

Potassium formate can be delivered as a solid or liquid. There are currently no producers of potassium formate or sodium formate in Canada or the United States. Potassium formate cannot rust steel and cannot poison animals. The Canadian government has finalized its decision that formic acid, ethyl formate, methyl formate and sodium formate, potassium formate do not warrant regulatory action under the Canadian Environmental Protection Act (CEPA). Canada

will not regulate formates for de-icing within the Canadian Environmental Protection Act (January 2018) since they are benign.

This final assessment concluded these chemicals are not in concentrations that are harmful to the environment or human health at current levels of exposure. Formates are used in a variety of industrial applications and consumer products, including: cosmetics; cleaners; food flavorings; and natural health products.

Concentration (%)	*Closed Loop Performance and*	*Open Loop Performance*
10%	14°F to 425°F / -10°C to 218°C	14°F to 212°F / -10°C to 100°C
20%	-4°F to 425°F / -20°C to 218°C	-4°F to 212°F / -20°C to 100°C
30%	-22°F to 425°F / -30°C to 218°C	-22°F to 212°F / -30°C to 100°C
40%	-40°F to 425°F / -40°C to 218°C	-40°F to 212°F / -40°C to 100°C
50%	-58°F to 425°F / -50°C to 218°C	-58°F to 230°F / -50°C to 110°C

Table 1: Potassium Formate Temperature Performance. A 20% solution de-ices at -4°F

Case Study: Road Tests in Finland in 2002

The Finnish Environment Institute conducted laboratory tests and pilot studies in 1998-2001 that demonstrated that potassium formate was the best alternative de-icing chemical available. Formate was applied on a test road in southeast Finland during the winter season of 2002-03, investigating roadworthiness and the biodegradation of potassium formate in shallow aquifers. The experiments using soil and groundwater samples were conducted to study the microbial degradation of potassium formate at a range of low temperatures. The monitoring program in Suomenniemi involved groundwater samples from a network of monitoring wells, private dug wells and water intake wells.

During the first monitored winter season, 5.4 tonnes of potassium formate per kilometre was applied on the test road. During the next winter, no harmful effects on groundwater quality were detected. Concentrations of dissolved oxygen, potassium and total organic carbon followed the usual seasonal variation and were unchanged compared to the earlier years. However, replacing sodium chloride with potassium formate yielded groundwater sodium and chloride concentrations that dropped up to 40% across the area under study.

Furthermore, test results indicated that conversion of formate into carbon dioxide and water occurs in the soil next to the road, thus preventing dispersion. After application during the first winter, potassium formate did not have any harmful effects on groundwater quality or vegetation near the road slopes. Monitoring of groundwater for possible delayed effects was continued into 2004. The program ultimately determined that potassium formate was very effective and benign.

Case Study: The Denver International Airport in 2017

The Denver International Airport has just recently tested the effectiveness of potassium formate as a de-icer over the winter of 2017-18. Using 4,000 gallons of liquid de-icer, they found the potassium formate performed as good as potassium acetate with 33% less chemical oxygen demand, leaving potassium formate to break down more readily after use. Biodegradable potassium formate also causes a lower environmental impact when seeping into waterways.

Denver airport crews applied the de-icers side by side in the exact same manner, so they could compare the performance of both. They used results from monitoring takeoff, landings, and

operations vehicles in order to perform friction tests on the runway and taxiway surfaces. In addition to its "green" advantages, the Denver International Airport found that less expensive potassium formate delivered the same de-icing results as the incumbent potassium acetate.

Because of its lowered impact on the environment and comparable de-icing results, the Denver International Airport decided that during the 2018-19 winter, they will accept bids from vendors for both potassium formate and potassium acetate for the upcoming winter ice season.

Potassium Formate and Sodium Formate – The Better Choice

Currently potassium acetate is the most commonly used airport runway, roadway, and bridge de-icer in North America. Potassium formate is not a chloride-based salt, which are corrosive and dangerous to surround environments and flora in the area. Formates can be produced renewably.

ChemBioPower will provide formic acid for the production of the less toxic de-icer in the form of potassium formate, a salt of formic acid. As mentioned, formate de-icers have significantly less impact on the environment and have become the de-icer of choice for most European airports.

Advantages of potassium formate (HCOOK) as a de-icer:

- Readily biodegradable, both potassium and the organic portion are good for soil
- Lower Chemical Oxygen Demand (COD) compared to acetates
- Ice-melting even at very low temperatures
- Can be formulated to meet the AMS 1435 for runways

About the Author

Dr. Antonio P. Anselmo

Antonio Anselmo is the President of ChemBioPower. The firm generates technology and systems for producing, storing and selling dimethyl ether (from methanol) as a clean fuel for compression engines, along with coolant, solvent and chemical applications. The firm also involved in the production of formates from forestry and farm biomass. The company also has intellectual property covering the production of household and automotive chemical products based on dimethyl ether and formic acid.

Dr. Anselmo worked for 12 years at J.P. Morgan Chase in the Financial Engineering and Electronic Commerce groups within the Investment Bank. He was also the pioneering leader of the e-commerce effort at Chase during the mid 90's. He was responsible for the development of many of the early derivative products used in structured debt, real options and asset/liability management. Prior to this, he was a Scientist at Varian Associates for 4 years.

He holds an M.B.A. from the Amos Tuck School at Dartmouth College and a B.Sc., M. Eng. and Ph.D. from Cornell University. Dr. Anselmo was named and Edward Tuck Scholar at Dartmouth and was awarded a Teagle Fellowship for research while at Cornell. Also at Tuck, he was named an Adams Award winner for Entrepreneurship.

At JP Morgan Chase, he was awarded the Top Tier Award for 2000 by his peers as a leading individual contributor in the Investment Bank. He has published over ten articles and has given over forty invited public talks.