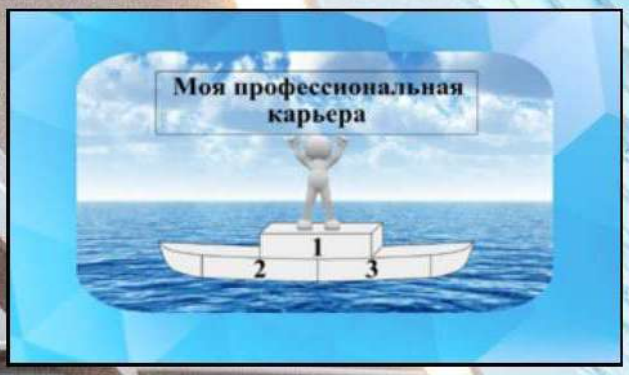

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Международный научно-образовательный электронный журнал «ОБРАЗОВАНИЕ И НАУКА В XXI ВЕКЕ». Выпуск №61-2 (том 2) (апрель, 2025). Дата выхода в свет: 14.04.2025.

Сборник содержит научные статьи отечественных и зарубежных авторов по экономическим, техническим, философским, юридическим и другим наукам.

Миссия научно-образовательного электронного журнала «ОБРАЗОВАНИЕ И НАУКА В XXI ВЕКЕ» состоит в поддержке интереса читателей к оригинальным исследованиям и инновационным подходам в различных тематических направлениях, которые способствуют распространению лучшей отечественной и зарубежной практики в интернет пространстве.

Целевая аудитория журнала охватывает работников сферы образования (воспитателей, педагогов, учителей, руководителей кружков) и школьников, интересующихся вопросами, освещаемыми в журнале.

Материалы публикуются в авторской редакции. За соблюдение законов об интеллектуальной собственности и за содержание статей ответственность несут авторы статей. Мнение редакции может не совпадать с мнением авторов статей. При использовании и заимствовании материалов ссылка на издание обязательна.

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Название публикации: «TECHNOLOGY FOR OBTAINING MIRABILITE-BASED DE-ICING AGENT»

Abstract: Winter road safety is heavily dependent on effective and environmentally sustainable de-icing agents. Sodium sulfate decahydrate, commonly known as mirabilite ($Na_2SO_4 \cdot 10H_2O$), has attracted attention as a potential alternative to conventional chloride-based de-icing salts due to its lower corrosivity and reduced environmental impact. This paper explores the technological process for obtaining a de-icing agent based on mirabilite, from raw material sourcing to crystallization, formulation, and application. The study includes methods of extraction from natural sources (salt lakes and brine), purification techniques, drying or granulation processes, and performance evaluation under varying temperature conditions. The paper also discusses the advantages of mirabilite-based de-icers in terms of cost, availability, environmental safety, and operational performance compared to traditional agents like sodium chloride and calcium chloride.

Keywords: Mirabilite, sodium sulfate, de-icing agent, anti-icing, crystallization, salt lakes, eco-friendly de-icer, corrosion reduction, winter road maintenance, alternative de-icing technology.

1. Introduction

Winter road maintenance is crucial for traffic safety and uninterrupted transportation. Traditionally, de-icing agents like sodium chloride (NaCl) and calcium chloride ($CaCl_2$) have been used extensively. However, they are associated with high environmental costs, including soil and water pollution, and the corrosion of vehicles and infrastructure.

Mirabilite ($Na_2SO_4 \cdot 10H_2O$), a naturally occurring mineral form of sodium sulfate, offers an environmentally friendly alternative. It is abundant in evaporitic deposits and brine-rich environments. This study presents the process technologies for obtaining and utilizing mirabilite in de-icing formulations, evaluating its efficiency, environmental footprint, and economic feasibility.

2. Chemical and Physical Properties of Mirabilite

Property	Value
Chemical Formula	$Na_2SO_4 \cdot 10H_2O$
Molar Mass	322.20 g/mol
Melting Point	~32.4°C (dehydrates)
Solubility in Water	19.5 g/100 mL (20°C)
Density (crystal)	~1.46 g/cm³
pH (aqueous solution)	~6–8

These properties make mirabilite suitable for slow, sustained release of active salt during freezing conditions and reduce corrosivity compared to chloride-based salts.

3. Sources and Raw Material Preparation

3.1 Natural Sources

- **Salt lakes**: e.g., Garabogazköl (Turkmenistan), Great Salt Lake (USA)
- **Brine deposits**: subterranean brine fields containing sodium sulfate
- **Industrial by-products**: Sodium sulfate may be obtained as a by-product from viscose rayon or detergent production.

3.2 Extraction Process

- **Sedimentation and mechanical harvesting**: From crystallized lake beds.
- **Vacuum evaporation**: For producing pure mirabilite from brines.
- **Cooling crystallization**: Natural cooling of concentrated sodium sulfate solution to form mirabilite crystals.

4. Technology of Mirabilite De-Icing Agent Production

4.1 Crystallization

Mirabilite is formed through **cooling crystallization** of saturated sodium sulfate solution.

Process steps:

1. Prepare saturated sodium sulfate solution.
2. Cool to ~5–10°C to initiate crystal formation.
3. Separate crystals via centrifugation or filtration.
4. Dry to reduce surface moisture.

4.2 Granulation and Formulation

- Crystals can be compacted or pelletized for easier spreading.
- Anti-caking agents (e.g., fine clay or silica) can be added.
- Optional additives include corrosion inhibitors (e.g., sodium gluconate, organic acids).

4.3 Packaging

- Stored in **moisture-resistant** packaging to prevent premature hydration loss.
- Bulk or bagged distribution formats are available.

5. Performance as a De-Icing Agent

5.1 Melting Action

- Effective down to −8°C, with slower ice melting compared to NaCl.
- Delivers a **sustained release** of active ions.
- Less aggressive to metals, concrete, and vegetation.

5.2 Comparative Analysis

Property	**NaCl**	**$CaCl_2$**	**Mirabilite**
Effective Temp.	−9°C	−25°C	−7 to −8°C
Corrosivity	High	Medium	Low
Environmental Impact	High	Medium-High	Low
Cost	Low	High	Medium
Application Rate	Medium	Low	Medium-High

6. Environmental and Economic Considerations

6.1 Environmental Advantages

- Chloride-free; avoids damage to roadside vegetation and water bodies.
- Lower impact on metal structures and rebar in reinforced concrete.

- Biodegradable additive compatibility.

6.2 Economic Feasibility

- Cost-effective in regions with abundant sodium sulfate resources.
- Lower maintenance and repair costs due to reduced corrosion.
- Can be integrated with existing salt-spreading infrastructure.

7. Challenges and Optimization

7.1 Limitations

- Lower de-icing power at very low temperatures.
- Hygroscopic nature may cause storage issues without proper handling.
- Larger application volume required compared to $CaCl_2$.

7.2 Innovations

- **Blended formulations**: Combining mirabilite with fast-acting salts or organic de-icers.
- **Encapsulation**: To extend shelf life and reduce moisture uptake.
- **Smart spreading systems**: Optimizing the quantity and distribution based on weather data.

8. Conclusion

Mirabilite-based de-icing agents offer a promising, eco-friendly alternative to traditional chloride salts. With proper extraction, crystallization, and formulation techniques, mirabilite can be transformed into an efficient and sustainable winter road maintenance product. Especially in regions with natural sodium sulfate deposits, this technology can play a vital role in reducing environmental damage and infrastructure corrosion, while maintaining road safety during winter.

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