Imidazoline Surfactants

Subjects: Chemistry, Applied

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Imidazoline surfactants are a class of surfactants with a hydrophobic tail and an imidazoline hydrophilic head. They are commonly used as emulsifiers, wetting agents, and cleaning agents in a variety of applications, including personal care, industrial cleaning, and agriculture. Imidazoline surfactants are known for their stability in acidic and alkaline conditions, making them a popular choice for many industrial processes. Imidazoline surfactants are mainly the cationic surfactants that contain an imidazoline ring in their chemical structure. They are commonly used as emulsifiers, corrosion inhibitors, and wetting agents in a variety of industrial and household applications. Imidazoline surfactants are typically synthesized by reacting a fatty acid or fatty amine with an imidazole or imidazoline compound. The resulting surfactants have a unique combination of properties, including excellent emulsification, wetting, and corrosion inhibition abilities.

surfactants imidazoline surfactants cationic imidazoline surfactants

1. Introduction

Surfactants are the amphillic molecules that have tendency to reduce the surface tension of liquids. Imidazoline is a five membered ring with two nitrogen atom within it. moreover, imidazoline surfactants are the amphillic molecules that has imidazoline ring as its polar moiety whereas a long hydrophobic tail is made up of hydrocarbon tail that may vary in size and unsaturation depends upon their fatty material source wether that is linear or branch, their size like its C12, C14, C16, ,,,, Cn etc. Due to its pendant like structure the imidazoline pendant group easily get attached to the surfaces whereas hydrophobic tail oriented towards outside [1][2][3][4][5][6][7][8][9].

Imidazoline surfactants have already gained enormous interest due to their broad range of applications. Due to their availability in cationic, nonionic and zwitterionic forms, they can be exploited in almost every industry. Moreover, easy conversion of onomeric to bis-gemini form increase their efficacy in many folds.

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2. History

The history of imidazoline surfactants dates back to the late 1940s and 1950s, when the first imidazoline-based surfactants were synthesized and studied for their potential applications. The discovery of imidazoline surfactants marked an important milestone in the development of surfactant chemistry and opened up new possibilities for the formulation of effective and stable surfactant systems.

Over the following decades, imidazoline surfactants have been extensively studied and developed, leading to the discovery of various types of imidazoline derivatives with unique properties. Today, imidazoline surfactants are widely used in a variety of industrial and consumer applications, including personal care, industrial cleaning, agriculture, and others. Their unique properties, such as stability in acidic and alkaline conditions, make them a popular choice for many industrial processes.

3. Classification

Imidazoline surfactants can be classified based on their chemical structure into two main categories:

1. Secondary Imidazolines: These are derivatives of 2-alkyl-2-imidazoline and have a single hydrophobic chain.

2. Tertiary Imidazolines: These have a hydrophobic chain attached to both the nitrogen and carbon atoms of the imidazoline ring.

Additionally, imidazoline surfactants can also be classified based on their chain length and degree of ethoxylation, which determines their surface activity, foaming properties, and solubility in water.

On the basis of charge on the head group, imidazolines surfactants are classified into cationic, anionic, nonionic and amphoteric surfactants.

1. Imidazoline surfactants can be synthesized in any form like **anionic imidazoline surfactants** for example (1,3-bis(tricyanoborane)imidazolate), nonionic imidazoline surfactants, zwitterionic imidazoline surfactants and cationic surfactants.

2. Cationic imidazolines can be hydroxyethyl, aminoethyl and amidoethyl types of imidazolines and can be used as a lubricant, paints, inks, adhesion increaser, corrosion inhibitors, dispersants, remoisturizing substances, flocculants, conditioners, etc.

3. Amphoteric imidazolines examples are alkylamphodiacetates, alkylaminopropionates, alkylphosphopropionates etc. and exploited as hair conditioners, fabric softeners, liquid soap, gel due to its comfortable pH.

4. Nonionic imidazoline surfactants can be found very useful as corrosion inhibitors and easily applicable in desalination plants whereas anionic imidazoline can be used in laundry detergents, agriculture and related industries.

Gemini imidazoline surfactants are the molecules that have two imizazoline surfactant monomers linkes via spacer. spacer can be present in between the head groups or in between the tails. Gemini imidazolines shows much lesser CMC values than their monomeric counterparts.

4. Synthesis

Imidazoline surfactants can be synthesized by reacting fatty acids and fatty alcohol with polyamines. Fatty acids and alcohols may be obtained from oil and fats and their reduced products. Oil may be obtained from plant source or animal source, edible or non-edible, essential or nonpessential. Length of hydrophobic chain depends upon the source taken from fatty material. Commonly used polyamines are diethylene tri amines, Hydroxyethyl ethanol amines etc.

Advance researches shows the use of waste resources to make them more cost effective. waste edible oil obtained after frying has proven as a great source to provide fatty alkyl chain to these molecules. This also help in recyclization of harmful waste oil after use. some examples of waste oil reported to synthesize the imidazolines or their geminis are soyabean oil, rice bran oil, rapeseed oil etc.

5. Properties

5.1. Physical Properties

Depends upon the type of hydrophobic tail, imidazoline may be crystalline solid to waxy solid, semi solid to viscous liquid, white, yellow or brown in color with varying melting and boiling point and different solubility and thermal stability. They are generally good water propellant with good lubricating properties and have ability to form acid stable salts.

5.2. Chemical Properties

Imidazoline surfactants have a unique combination of chemical properties that distinguish them from other surfactants. Some of the key chemical properties of imidazoline surfactants include:

1. Hydrophilic-Lipophilic Balance (HLB): Imidazoline surfactants have an intermediate HLB value, which allows them to effectively stabilize oil-in-water emulsions.

2. Acid-Base Stability: Imidazoline surfactants are highly stable in acidic and alkaline conditions, making them a popular choice for many industrial processes that require high pH stability.

3. Solubility: Imidazoline surfactants are soluble in water and organic solvents, making them useful in a variety of applications.

4. Surface activity: Imidazoline surfactants have a unique combination of surface activity and wetting properties, making them effective at reducing the surface tension of liquids and increasing their ability to penetrate porous surfaces.

5. Compatibility: Imidazoline surfactants are compatible with a wide range of surfactants and other ingredients, making them useful in formulations that require multiple components.

These properties, in combination with their low toxicity and biodegradability, make imidazoline surfactants a popular choice for many industrial and consumer applications.

6. Applications

Imidazoline surfactants can be metered into the washing machines automatically and showed good potential to remove dirt and oil from the fabrics, their property to impart softness to fabrics make them good laundry detergents. Good fabric softening and resiliency tendency of imidazoline surfactants encorage their usage in commercial fabric softeners. Property of imidazolines to inhibit agglomeration make them efficient dispersants and applicable in paints and varnishes. These compounds also show antistatic-ness and found useful dewatering agents. Good absorbency on fabrics makes them to be exploited as rewetting agents. Some research also revealed their employability as bleach activators. These compounds show good degradability and are mild to eyes and skin so can be used in skin preparations. Water-repellent tendency aided their use as corrosion inhibitors. Other uses involve car washing, flocculants, oil and grease thickeners, Agriculture spray, paints, pharmacology and many more.

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