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Account/Revue

Synthesis, chemistry, physicochemical properties and industrial applications of amino acid surfactants: A review

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ABSTRACT

Surfactant use throughout mankind is extensive, from their initial applications as detergents extending to use in medicine, lubricant, cosmetics and even enhanced oil recovery. However, the image of surfactant use has in the past been tarnished by issues with low biodegradability and their synthesis from nonsustainable resources. Amino acid–based surfactants are a class of surfactants derived from a hydrophobe source coupled with simple amino acids, mixed amino acids from synthesis or from protein hydrolysates, and as such can be derived solely from renewable resources. There are several pathways for their synthesis and this allows for extensive structural diversity in this class of surfactants, resulting in widespread tuneable functionality in their physiochemical properties. This review includes the details of most of the available routes of synthesis for amino acid surfactants (AASs) and the impact of the diverse routes on their final physiochemical properties, including solubility, dispersability, toxicity and biodegradability. The diversity offered by the structural variation in AASs offers many exciting commercial opportunities for this ever-growing class of surfactants. It also includes a discussion on current and future potential uses of AASs.

1. Introduction

Surfactants are the group of organic compounds that continue to attract great interest from researchers because of their wide range of applications as laundry detergents, emulsifiers, corrosion inhibitors, oil recovery and pharmaceuticals. These are the most representative chemical products to be consumed in major quantities daily and globally and have in the past led to adverse effects on the aquatic environment. Many studies have previously revealed the adverse impact of widespread use of conventional surface active agents on the environment [1]. As such nontoxicity, biodegradability and biocompatibility of surfactants have become almost equally important for the consumers as their functional performance.

Biosurfactants are a class of green and sustainable surface active agents naturally synthesized from microorganisms such as bacteria, fungi and yeast or excreted extracellularly. Synthetic equivalents to biosurfactants can therefore be prepared by designing molecules that imitate natural amphiphilic structures such as phospholipids, alkyl glucosides and acyl amino acids. Amino acid surfactants (AASs) are one such type of surfactant that can generally be originated from animal or agricultural-derived feedstocks. AASs have been gaining great interest of scientists over the last two decades as novel surfactants because they can be synthesized using renewable sources and their ease of

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degradability and harmless byproduct make them safer for our environment [2].

AASs can be defined as a group of surfactants made up of amino acids comprising amino acid group (HO_2C-CHR-NH_2) or its residue (HO_2C-CHR-NH_2). These two functional regions of amino acids give the possibility to derive an extensive range of surfactants. There are total of 20 standard proteinogenic amino acids known in nature, which are responsible for growth and all physiological reactions of living kingdom. They differ from each other only on the basis of the residue, R [3] (Fig. 1). Some are nonpolar and hydrophobic, others are polar and hydrophilic, some are basic and some are acidic. As amino acids are renewable compounds, surfactants synthesized from amino acids also have great potential as sustainable and eco-friendly substances [4]. Simple and natural structure, low toxicity and fast biodegradation often make them superior to their conventional counterparts. Their production can be via different biotechnological and chemical routes using renewable raw materials such as amino acids and vegetable oils.

Amino acids were first discovered as a substrate for surfactants in the early 20th century [5]. Primarily they were used as preservatives in pharmaceuticals and cosmetic formulations. Furthermore, they were found to be biologically active against a variety of disease-causing bacteria, tumors and viruses [6]. In 1988, availability of AASs at low cost increased the interest of researchers to study their surface activity [7]. Nowadays, along with the growth of biotechnology, a few amino acids are also able to be synthesized commercially at a large scale by yeasts, thus justifying their production to be more environmental friendly [8].

2. History

The value of the structures of naturally occurring amino acids as raw materials for preparing amphiphiles was predicted as soon as they were discovered early in the 19th century. The first research on AAS synthesis was reported in 1909 by Bondi [9]. In that study, *N*-acylglycine and *N*-acylalamine as hydrophilic moieties of surfactants have been

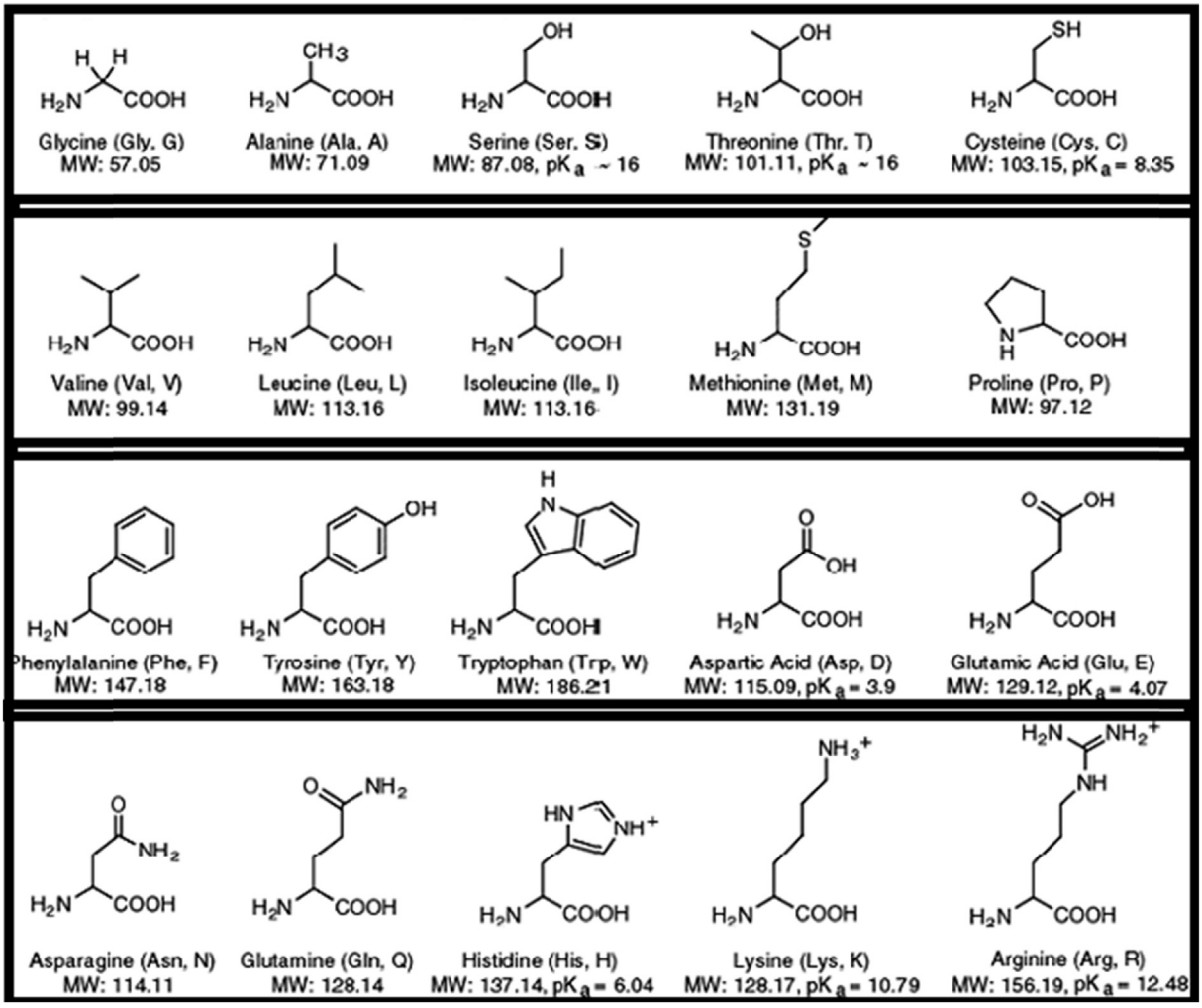

Fig. 1. Twenty standard amino acids. pK_a is the negative base-10 logarithm of the acid dissociation constant (K_a) of a solution. $pK_a = -\log_{10} K_a$.

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