Experimental determination of distribution coefficients of gluconic acid between H_2O and organic solvents

Chrysoula C. Michailof, Asimina A. Marianou, Maria G. Misia, Stamatia A. Karakoulia, Angelos A. Lappas

Chemical Process & Energy Resources Institute, 6th km Harilaou-Thermi Road, 57001, Thessaloniki, Greece.

Over the last couple of decades, the scientific community has witnessed and participated in an auspicious global plan aiming to the valorization of inedible and waste biomass, mainly towards fuels and chemicals. In this framework, the synthesis of gluconic acid, a carboxylic acid formed by glucose oxidation, has attracted increased interest due to its numerous applications in the industrial sectors of foods and pharmaceuticals. Currently, gluconic acid is produced biotechnologically via fermentation, followed by downstream purification protocols that consist the bottleneck of the process. The recovery of gluconic acid from fermentation broth involves the use of inorganic bases, i.e. to precipitate the corresponding calcium salt, as well as inorganic acids, in order to liberate gluconic acid[1]. Thus, undesirable salts are formed while the use of inorganic acids and bases is also unfavorable. Generally, on industrial level liquid-liquid extraction (LLE) with conventional organic solvents remains the most widely applied method for the recovery of chemicals from reaction solutions, as it has low requirements in terms of equipment and is easily implemented[2]. The selection of the proper solvent for LLE of gluconic acid is based on the accurate determination of the corresponding distribution coefficients, as is the scope of this work. Such data have only scarcely been reported in the literature[3].

In this study, the distribution coefficients of gluconic acid between H_2O and six commonly used industrial solvents (ethyl acetate, MIBK, Me-THF, di-isopropyl ether, dichloromethane and 2-butanol) were determined, at 4 levels of temperature (25-55 ^oC). The concentration of the acid in the aqueous solution before and after contact with the solvent was determined by Ion Chromatography. The distribution coefficient was calculated according to the equation $P_{A\,i,j} = \frac{C_{A\,i}}{C_{A\,j}}$, where A is the substance distributing between solvents i (initial solvent) and j (extracting solvent). Subsequently, for the best performing organic solvent the presence of tertiary and quaternary amines as complexing agents for gluconic acid as well as the salting out effect, were also examined.

According to experimental results, it was confirmed that gluconic acid is a very hydrophilic compound which is not easily extracted from water. Among the solvents tested, 2-butanol proved to be the most efficient extracting agent, as almost 50% extraction of gluconic acid from water was achieved at 45 ^oC. The extraction efficiency was improved by adding trioctylamine (TOA) to 2-butanol, while trioctylphosphine oxide (TOPO) did not have an equally positive effect.

References

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