Foaming in gas sweetening process: Comprehensive experimental efforts lead to better understanding and predication of amine foaming

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Abstract

In order to explore the foaming behaviour of aqueous Methyldiethanolamine (MDEA) in the presence of twenty distinct contaminants, including breakdown products, extensive experimental work was carried out. N,N,N-tris-(hydroxyethyl) ethylenediamine (THEED), hydroxyethyl ethylenediamine (HEED), N,N/-bis-(hydroxyethyl) piperazine (bHEP), N,Nbis-(2-hydroxyethyl) glycine (bicine), organic acids, and liquid organics are all examples of N,N,N-tris-(hydroxyethyl) ethylene. To further understand foaming behaviour, this foaming investigation was paired with physical characterisation of the studied solution. In terms of foam volume, the foaming propensity of aqueous MDEA solution was observed. The time it took for the final bubble to burst was used to determine foam stability. The findings of this investigation revealed that each contaminant altered foaming behaviour by altering foam volume, breaking time, or both. However, whatever contaminants are added to the amine solution, the physical characteristics of the amine are dragged to a point where the foaming behaviour is altered. The addition of THEED and HEED, for example, enhanced the foam propensity and stability of the solution by raising the solution viscosity; higher bulk viscosity prevents foam collapse induced by gravity drainage. Predicting and monitoring the physical characteristics behaviour and interaction is thought to be the bottleneck in predicting the foam behaviour of any solution. We're now striving to better understand the interaction between physical characteristics and their combined influence on the amine solution's foaming behaviour, which will lead to a breakthrough in foaming monitoring and prediction. This research presents mathematical models of foaming propensity and stability to explain the influence of physical variables on foam volume and breaking time of aqueous MDEA solutions. Amine systems that use alkanolamines for acid gas absorption such as methyldiethanolamine (MDEA) have a constant challenge in terms of sustaining and growing process throughput and profit. Contaminants such as heat stable salts (HSS) and heavy metal ions, on the other hand, obstruct smooth operation and create system downtime and upsets. These HSS are produced by the reaction of MDEA with acid gases (H2S and CO2), followed by the reaction of the protonated MDEA (MDEAH+) with strong acid anionic species such as formate, acetate, propionate, thiosulfate, and others, and cannot be regenerated by heat. The presence of HSS in the amine degrades the solvent quality, diminishes H2S absorption capacity, and increases foaming, resulting in considerable MDEA loss. Fouling of the equipment, on the other hand, is caused by metal impurities in the makeup water or by corrosion or erosion induced by the plant's continual operation. As a result, amine reclamation, which reduces these contaminants to lower levels, has become a vital step for the gas sector to take in order to improve operations considerably. Few attempts to remove HSS breakdown products and heavy metal ions from contaminated amine solutions using neutralisation, vacuum distillation, electro dialysis, ion-exchange, and adsorption have been documented in the literature. Solid sorbent adsorption has attracted a lot of attention because of its high removal effectiveness, capacity to remove even residues of pollutants, and inexpensive operating, installation, and regeneration costs.

Researchers have recently stepped up their efforts in the hunt for low-cost, biodegradable materials with strong sorption capabilities, dubbed "green sorbents," for pollutant removal from industrial lean amine. Alginates have the capacity to crosslink with metal ions to generate hydrogels that can contain a considerable quantity of water. These hydrogels are three-dimensional networks made up of carboxylic (–COOH) and hydroxyl (–OH) groups that allow heavy metals and total organic acids to be removed simultaneously from industrial lean MDEA (LA) solutions through ion exchange and electrostatic interaction, respectively. However, both the gel and dry forms of alginate have limitations, such as low mechanical strength and swelling issues, posing operational challenges.

Researchers have proposed mixing relatively low-cost clay materials with ecologically friendly alginate to create a new class of hybrid materials known as bio composites, therefore reducing the inherent difficulties associated with alginate sorbents. The most effective composite material for simultaneous removal of TOA and heavy metals from industrial lean amine solutions was developed by incorporating alginate into a network of layered silicates belonging to the smectite family such as montmorillonites, bentonite, and microfibrous clays such as sepiolite. Alhseinat et al. recently published research that demonstrated the considerable influence of several organic acids on foaming behaviour. The goal of this study is to determine the efficacy of contaminant (TOA anions and heavy metal ions) removal from industrial lean MDEA solutions by adsorption utilising alginate clay composites comprising bentonite and sepiolite (CAS), as well as the impact on amine foaming. There is no published literature that addresses MDEA foamability and adsorption combined, to the best of the authors' knowledge. The sorption process and underlying principle were studied using SEM, FTIR, and EDX analysis, while the rate-controlling processes were studied utilising uptake kinetics. Additionally, foaming tests were used to assess the impact of pollutant cleanup

on amine foaming.

Biography

Dr. Alhseinat is currently an Assistant Professor of Chemical Engineering at Khalifa University. Prior to join Khalifa University, Dr. Alhseinat completed his PhD from the University of Edinburgh. Then he worked in Abu Dhabi Petroleum Institute as Research and Teaching Associate; where he was heavily involved in research activity, writing and preparing scientific proposals and presentations, and publishing scientific articles. His current research activities address the development of novel separation processes compatible with renewable energy i.e. Magnetic nanoparticles, Electrical and Magnetic separation technologies, Foaming predication and monitoring, thermodynamics modelling and thermophysical properties characterization, Desalination and Water treatment, and Fouling science.

This work is partly presented at 2nd International Conference on Advances in Chemical Engineering and Technology

November 16-17, 2017 | Paris, France