Renewable and Sustainable Energy Reviews 65 (2016) 101–112

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Eco Friendly nanocomposite materials to scavenge hazard gas H_2S through fixed-bed reactor in petroleum application

Ibrahim M. Nassar [a,*], M.R. Noor El-Din [a], R.E. Morsi [a], A. Abd El-Azeim [b], A.I. Hashem [c]

[a] Egyptian Petroleum Research Institute (EPRI), 1 Ahmed El-Zomor St., Nasr City 11727, Cairo, Egypt
[b] Khalda Petroleum Company, Cairo, Egypt
[c] Faculty of Science, Ain Shams University, Abassia, Cairo, Egypt

ARTICLE INFO

Article history:
Received 11 February 2015
Received in revised form
27 January 2016
Accepted 16 June 2016

Keywords:
CdS
H_2S gas
H_2S removal
Nanocomposite
Natural gas
Polymer

ABSTRACT

Hydrogen sulfide is a very dangerous, toxic and corrosive gas. It can diffuse into drilling fluid from formations during drilling of gas and oil wells. Hydrogen sulfide should be removed from this fluid to reduce the environmental pollution, protect the health of drilling workers and prevent corrosion of pipelines and equipment. Hydrogen sulfide (H_2S) is an environmentally hazardous, corrosive, and toxic gas, mostly generated in gas and oil industry.

In this work, we aimed to introduce a novel and effective materials to scavenge this gas as we were looking to reduce their concentration below standard limit. Team of the work synthesized three co-polymers based on acrylamide (AM) and vinyl acetate (VA) with average molecular weight 3.05×105 by the reacting of free radical precipitation polymerization method, this co-polymer were used in a three different molar ratios (3:1, 1:1, 1:3 namely; AMVA1, AMVA2 and AMVA3, respectively). The other part of nanocomposite was CdO nanoparticle, which synthesized by chemical method with particle size 8.8 nm. The efficiency of four compounds based on CdO/AMVA2 was discussed here. Consequently, formation of CdS nanoparticles (9.7 nm) and CdS/sulfide poly (acryl amide - vinyl acetate) (CdO/SAMAV) nanocomposites as a result from our process to remove H_2S gas, which using as natural source of sulfur metal were studied. The structures of the prepared adsorbents were elucidated using Fourier-transform infrared (FT-IR), X-ray diffraction (XRD) and scan electron microscopy (SEM), also the breakthrough behaviors of H_2S gas adsorption in the prepared adsorbents (polymers, CdO and CdO/AMVA2 nanocomposites) fixed-bed reactor were studied.

In the present work we were studied the effects of inlet H_2S gas concentration in gas streams from 10 to 55 ppm, variable gas flow rates from 1 to 7 l/h on the sulfur loading, the impact of operating temperature from -10 to 70 °C on the efficiency of the polymer (AMAV2) bed, and the effect of the prepared adsorbents on uptake of H_2S gas at constant operating conditions. The results obtained showed that our materials present an effectiveness, promising and relatively new candidate materials in the field of H_2S scavengers.

Contents

* Corresponding author.
E-mail address: inassar_76@yahoo.com (I.M. Nassar).

http://dx.doi.org/10.1016/j.rser.2016.06.019
1364-0321/

1. Introduction

Hydrogen sulphide is a colorless, toxic gas with a rotten-egg-like smell, whereas, it was emitted from oil and gas operations, routinely or accidentally, involve extraction, storage, transport, or processing stages. During extraction, hydrogen sulfide may be released into the atmosphere at wellheads, pumps, piping, separation devices, oil storage tanks, water storage vessels, and during flaring operations. Due to its high toxicity and corrosive, hydrogen sulfide can cause drill broken down and corrosion of oil and gas pipeline and it is environmentally dangerous. This imposes a serious threat to each process of drilling, well completion, perforating, gas test, exploiting, transportation, laborers and so on [1].

The removal or scavenge of acid gas impurities, such as CO_2 and H_2S, from industrial gas streams is a significant operation in natural gas processing, hydrogen purifying, refinery off-gas treating and synthesis gas for ammonia and methanol manufacturing. The industrial gas streams containing acid gas impurities must be purified in order to meet the requirements of the gas mixtures sequential processing (e.g., avoiding catalyst damage) or environmental regulation (exhaust of the gas mixtures as off-gas) [2]. The available methods to scavenge the gases can be largely divided into physical, chemical and biochemical [3].

The expression “Sulfur Scavenging” is used to describe a group of processes which operate in a non-regenerative manner to remove small quantities of sulfur compounds, usually H_2S, from gas streams. Sulfur scavenging processes are typically batched operations. They make use of materials that capture and retain sulfur compounds, but have a finite effective capacity. When this capacity is reached the spent sorbent (liquid or solid), must be removed and replaced with fresh material. The spent sorbent is normally disposed of as waste, and the production of an environmentally acceptable waste has become a key factor in the selection of scavenging processes for specific applications [4,5].

A scavenger should meet a number of criteria to be effective such as; Product should be able to efficiently remove all sulphide species under field conditions of pH, pressure and temperature, the reaction should be reliable, rapid and irreversible, reaction products should be easy to dispose to the environment, the chemical should not sow incompatibilities with other components of the fluids, the chemical overdosing should not give rise to system difficulties, the chemical should not be corrosive, the chemical should be safe to handle and non-polluting to the environment, and the chemical should be readily available and cost-effective.

Different scavengers were used in this field and we can summarize; Water-soluble scavengers are among the most common scavengers and are often the product of choice for applications at temperatures below (200 °F) [6]. Oil-soluble scavengers are used in high-temperature applications or when water tolerance of the hydrocarbon is an issue [7]. Metal-based scavengers answer the specific needs of very high temperature and high- H2S concentration applications. These additives can be used at temperatures above 177 °C to form thermally stable products and are able to provide H_2S reduction levels that other H_2S scavengers cannot achieve [8]. While we found a lot of technologies used in H_2S scavengers herein we give short idea about one of them which namely dry sorption processes.

Dry sorption processes, this section covers processes which scavenge H_2S and related sulfur compounds from gas streams by reaction with a solid at elevated temperature, such as iron oxide. Zinc oxide, Zinc Oxide-Based Processes can be classified as; high temperature processes and low-temperature process [9]. Alkaline solids, strongly alkaline solids as sodium hydroxide/lime granules are effective reagents for removing hydrogen sulfide by a simple acid base reaction. Molecular sieves adsorbents, Activated carbon and impregnated activated carbon are effective adsorbents for hydrogen sulfide and higher molecular weight sulfur compounds and are often used in scavenger-type operations. Polymers, there has not been significant research done on using polymers as adsorbents for H_2S, but a study was found where polymers were used in conjunction with other materials to enhance adsorption.

The H_2S scavenge from a gas stream can be accomplished by adsorption onto a solid surface, catalytic oxidation, and absorption by a liquid solution (amine/alkaloamine) [10]. However, various problems exist with the catalysts used in these processes, including the cost of renewing the inactivated catalysts, the generation of secondary substances causing pollution and the high-energy requirement [11]. One method, which is commonly used to overcome the problems associated with the chemical treatment of H_2S, oxidation into elemental sulfur, using a metal chelating agent in the form of a liquid catalyst, this method uses metal ions, such as Fe^{+2}, and various chelating agents, such as; ethylenediaminetetra acetic acid (EDTA) and nitrilo tri-acetic acid (NTA), which are non-toxic, and therefore, there is no environmental pollution during the removal of H_2S [12,13]. Another method is sorbent injection into the gasifier. In situ desulfurization can be