

Catalysts and Processes for H₂S Conversion to Sulfur

Daniela Barba

Department of Industrial Engineering, University of Salerno, Giovanni Paolo II, 132, 84084 Fisciano, Italy;
dbarba@unisa.it

The hydrogen sulfide (H₂S) is one of the main byproducts in natural gas plants, refineries, heavy oil upgraders, and metallurgical processes. It is a toxic gas and is classified as hazardous industrial waste. The exploitation of hydrogen sulfide as fuel using conventional combustion technologies is forbidden and criminalized by the more stringent environmental policies due to its deleterious effect like the SO₂ formation, which is the main responsible for acidic precipitation. There are different technologies for the removal of hydrogen sulfide but are characterized by high costs and limited H₂S conversion efficiency. Hydrogen Sulfide is usually removed by the well-known Claus process, which is mainly used in refineries, natural gas processing plants for the treatment of rich-H₂S gas streams, but it is not economically profitable because the hydrogen is lost as water. An interesting alternative could be to produce simultaneously sulfur and hydrogen by thermal catalytic decomposition of H₂S, even if the amount of energy requested to achieve extremely high temperatures, a low hydrogen yield and the need for subsequent separation stages represent the main drawbacks to an industrial application.

Therefore, the challenge is to realize the H₂S abatement in a one-reaction step in the presence of an active catalyst and very selective to sulfur already at low temperature. The choice of the catalyst plays a fundamental role in assuring a high grade of H₂S removal with a lower selectivity to SO₂.

Consequently, the development of innovative processes, or also the optimization of the most common technologies employing new catalysts for the H₂S abatement, is welcomed to the Special Issue “Catalysts and Processes for H₂S Conversion to Sulfur”.

The Special Issue is particularly devoted to the preparation of novel powdered/structured supported catalysts and the physical-chemical characterization, to the study of the aspects concerning the stability, reusability as well as of phenomena that could underlie the deactivation of the catalyst. The Special Issue covers also the kinetic modelling of the reaction system, by the identification of the main reactions to provide information about the reaction mechanisms, allowing so to optimize the reactor design, maximizing the activity of the catalyst.

This special issue contains 7 articles and 1 communication regarding the desulfurization of sour gases and fuel oil, the synthesis of novel adsorbents and catalysts for the H₂S abatement. In the following, a brief description of the papers included in this issue is provided to serve as an outline to encourage further reading.

Chen et al. have investigated porous carbonaceous materials for the reduction of H₂S emission during swine manure agitation. Two biochars, highly alkaline and porous made from corn stover and red oak were tested. The authors have verified the possibility of using surficial biochar treatment for short-term mitigation of H₂S emissions during and shortly after manure agitation [1].

Bao et al. have used the waste solid as a wet absorbent to purify the H₂S and phosphine from industrial tail gas. The reaction mechanism of simultaneous removal of H₂S and phosphine by manganese slag slurry was investigated. Best efficiency removal of both H₂S and phosphine was obtained by the modified manganese slag slurry [2].

The desulfurization of sour gases was studied by Duong-Viet et al., over car-

Citation: Barba, D. Catalysts and Processes for H₂S Conversion to Sulfur. *Catalysts* **2021**, *11*, 903. <https://doi.org/10.3390/catal11080903>

Received: 13 July 2021

Accepted: 24 July 2021

Published: 26 July 2021

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bon-based nanomaterials in the form of N-doped networks by the coating of a ceramic SiC. The chemical and morphological properties of the nano-doped carbon phase/SiC-based composite were controlled to get more effective and robust catalysts able to remove H₂S from sour gases under severe desulfurization conditions such as high GHSV and concentrations of aromatics as sour gas stream contaminants [3].

Li et al., have carried out the oxidative desulfurization of fuel oil for the removal of dibenzothiophene by using imidazole-based polyoxometalate dicationic ionic liquids. Three kinds of catalyst were synthesized and tested under different conditions [4]. The catalytic performance of the catalysts was studied under different conditions by removing the dibenzothiophene from model oil. The authors have identified a catalyst with an excellent DBT removal efficiency under optimal operating conditions.

The H₂S and SO₂ removal at low temperature was investigated by Ahmad et al., over eco-friendly sorbents from the raw and calcined eggshells. They have studied the effect of relative humidity and reaction temperatures. The best adsorption capacity for H₂S and SO₂ were obtained at a high calcination temperature of eggshell [5].

Zulkefli et al. have prepared a zinc acetate supported over the commercial activated carbon for the H₂S capture by adsorption. The optimization conditions for the adsorbent synthesis were carried out using RSM and the Box–Behnken experimental design. Several factors and levels were evaluated, including the zinc acetate molarity, soaked period, and soaked temperature, along with the response of the H₂S adsorption capacity and the surface area [6].

Vanadium-sulfide-based catalysts supported on ceria were used for the direct and selective oxidation of H₂S to sulfur and water at a lower temperature. Barba et al. have performed a screening of catalysts with different vanadium loading in order to study the catalytic performance in terms of H₂S conversion and SO₂ selectivity. The effect of the temperature, contact time, and H₂S inlet concentration was studied over the catalyst that has exhibited the highest H₂S removal efficiency and the lowest SO₂ selectivity [7].

The H₂S adsorption was studied over a novel kind of hydrochar adsorbent derived from chitosan or starch and modified by CuO-ZnO. Zang et al., have investigated the formation of CuO-ZnO on hydrochar, the effect of the hydrochar species, the adsorption temperature and the adsorption mechanism [8].

As Guest Editor, I would like to thank all the authors who contributed to this Special Issue. Their contributions represent interesting and innovative examples of the current research trends in the field of H₂S removal from liquid and gas streams.

I also wish to thank the editorial staff of Catalysts for their help to organize this issue.

I hope that the topics presented in this issue will inspire readers to further investigate new materials and solutions to reduce significantly the presence of pollutants such as H₂S, SO₂ and other sulfur-based compounds, and so pursuing the objective of “zero emissions” in the atmosphere.

Funding: This research received no external funding.

Conflicts of Interest: The author declares no conflict of interest.

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