ISCRE25
FLORENCE 2018
BRIDGING
SCIENCE & TECHNOLOGY
The 25th International Symposium
on Chemical Reaction Engineering
20-23 May 2018
Florence, Italy
www.aidic.it/iscre25

# Low Temperature $H_2S$ Removal from CO with High Activity Sorbent

Pankaj Gautam[1*], Zhe Sun[2] and Tian Gu[1]

*1 SABIC, Sugarland, TX 77478, United States; 2 University of Houston, Houston, TX 77204, United States*

**Corresponding author: pgautam@sabic.com*

***Highlights***

- Sorbent found to effectively remove $H_2S$ from CO at near ambient temperature (<50°C).
- A mathematical model developed and validated using literature and experimental data.
- Analytical solution derived for predicting breakthrough time.
- Parametric studies showed impact of various design parameters and operating conditions.

## 1. Introduction

Hydrogen sulfide $H_2S$ is a common impurity found in chemical feedstocks that poisons many common industrial catalysts. Although extensive research has been carried out to remove $H_2S$ from gas mixtures, particularly natural gas, no study reports $H_2S$ removal at ambient temperatures specifically from CO stream in our knowledge. Such conditions occur while removing $H_2S$ from the gas mixture produced out of incomplete combustion of petroleum coke. Among various reactive sorbents commonly used in natural gas desulfurization [1], we found one reactive sorbent that effectively removes $H_2S$ from a reducing CO stream at ambient temperatures.

## 2. Methods

Reactive sorbents are tested in lab-scale reactors at 40°C under 8.6 barg pressure, with a feed of 95% CO, 4.9% $CO_2$ and ~1000 ppm $H_2S$. Sulfur breakthrough is monitored at the exit and experiments are stopped when either $H_2S$ or COS breaks through.

The unreacted core model [2, 3] is used to describe $H_2S$ capture process in reactive sorbents, with the apparent reaction rate determined by the combination of external mass transfer, intra-particle diffusion and surface reaction. An analytical solution is obtained using simplifying assumptions.

## 3. Results and discussion

As shown in Fig. 1, the selected reactive sorbent shows high efficiency in $H_2S$ removal at low temperature, where the breakthrough occurs at t ≈ 30h and the exit $H_2S$ level is below 30 ppm for 100 hours. Model parameters are fitted to the experimental data. Due to the high surface area and high operating pressure, the overall reaction rate is strongly influenced by internal and external mass transfer resistances even at low temperature. The model is used to design an industrial scale $H_2S$ removal reactor. Impact of various design parameters and operating conditions on the bed life are studied, with some important ones shown in Fig. 2. In the regime of intra-particle diffusion control, an analytical formula is derived to relate the dimensionless bed life to the local Peclet number ($P_m$') and the dimensionless capacity ($\hat{W}$) ,

$$\hat{t}_b = \frac{t_b}{\tau} = 1.12\widehat{W}\left[1 - \frac{(ab)^3(2ab - a + 2)}{2(ab+1)^2(ab - a + 1)^2}\right]; \quad a = 1 - \frac{\omega_{H_2S}^{out}}{\omega_{H_2S}^{in}}; \quad b = \frac{P_m{}'}{12(1-\epsilon)}; \quad \widehat{W} = \frac{\rho_b W}{\rho_f \omega_{H_2S}^{in}}; \quad P_m{}' = \frac{d_p^2}{D_{eff}\tau}$$

The analytical correlation (dashed lines) shows very good agreement with detailed model results (markers).

## 4. Conclusions

We have discovered a reactive sorbent that effectively removes $H_2S$ from CO stream at near ambient temperature. A mathematical model is developed and validated using experimental data, then simplified to an analytical formula to predict bed life.

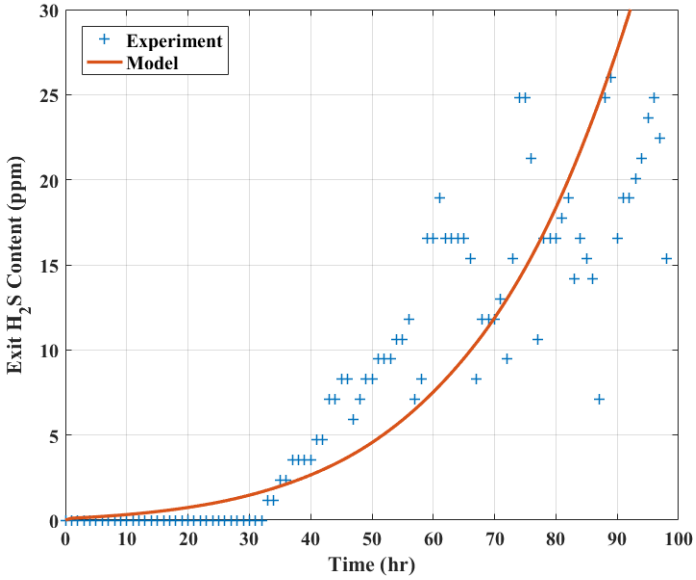


**Figure 1.** Breakthrough curves for the selected sorbent.

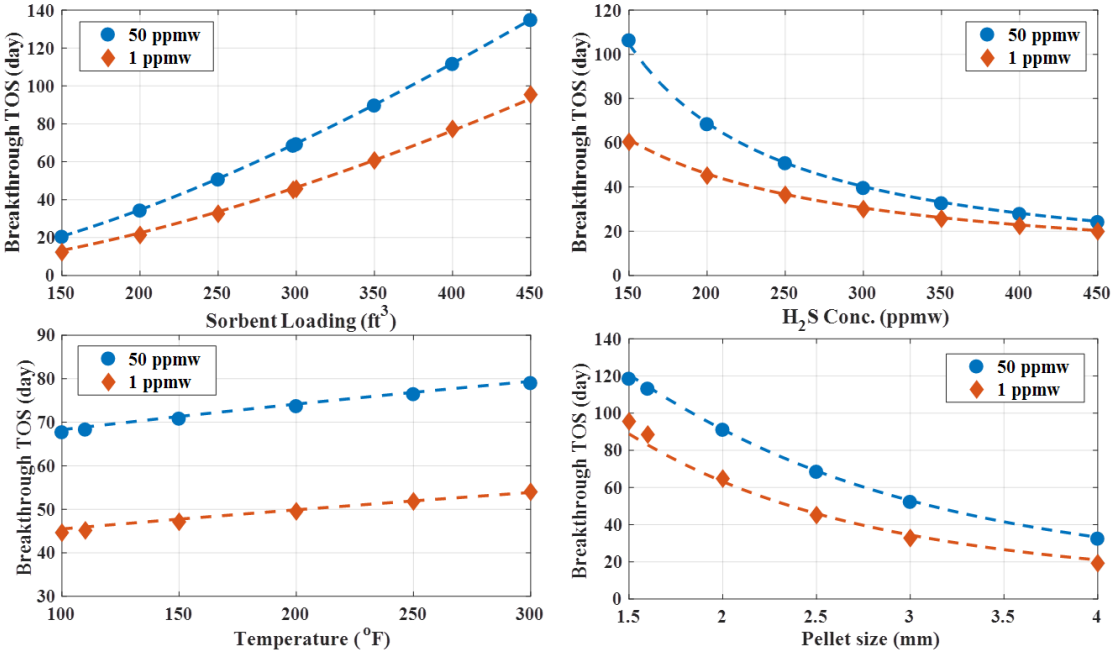


**Figure 2.** Impact of various parameters on breakthrough time. Numerical model results are shown in markers and the analytical correlation results are shown in dashed lines.

## References

[1] A. Samokhvalov, B.J. Tatarchuk, Phys. Chem. Chem. Phys. 13.8 (2011) 3197-3209.
[2] I.I. Novochinskii, C. Song, X. Ma, X. Liu, L. Shore, J. Lampert, R.J. Farrauto, Energy & Fuels, 18 (2004) 576-583
[3] I. Rosso, C. Galletti, M. Bizzi, G. Saacco, V. Specchia, Ind. Eng. Chem. Res., 42(2003)1688-1697.

***Keywords***
Desulfurization; $H_2S$ removal; Reactor modeling