

to be due to polarization with no dispersion contribution at all.

It appears therefore that the adsorption of simple molecules in Henry's Law region may give a measure of the electrostatic fields in near-faujasite. Further work along these lines is now in progress in our laboratory.

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Temperature Profiles in a Rapidly Fouling Catalyst Bed

If the product of a catalytic reaction covers the catalyst surface, the activity of the catalyst will decrease rapidly. In a fixed-bed reactor for an exothermic reaction this will lead to a nonstationary state as follows: Consider an intermediate layer A (Fig. 1) in the catalyst bed. In the beginning the catalyst layers above A are getting fouled. The concentrations of the reactants reaching A will be small and the heat of the reaction liberated in A will also be small. As the layers above A are progressively fouled, the concentration of reactants arriving, and hence the reaction rate and heat liberation, in A will increase steadily. Soon the catalyst in this zone is fouled and the rate and heat liberation fall. Similarly, the lower layers of catalyst also experience in turn increasing rate and higher temperature followed by a fall in both. Thus a zone of highest activity and highest temperature moves through the catalyst bed as a function of time. Froment and Bischoff (1) have analyzed such a nonstationary system in the formation of carbonaceous deposits on catalysts in a reaction parallel or consecutive to the main reaction; for the latter case they have

predicted that both the rate and temperature profiles should exhibit peak values the loci of which travel through the reactor as time increases.

Such nonstationary situations can also

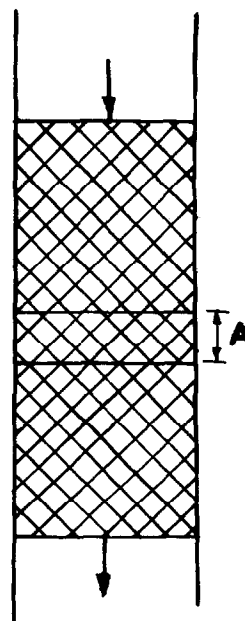


Fig. 1. Diagram of catalyst bed.

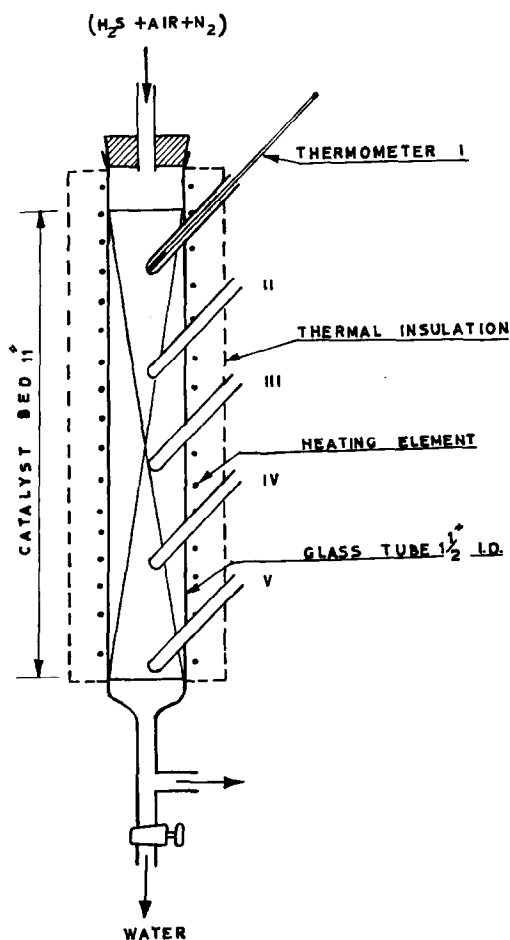
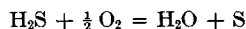


FIG. 2. Reactor used for studying temperature profiles. (Only one thermometer is shown.)

arise in the oxidation of carbon deposits on silica-alumina cracking catalysts, where the heat of the reaction may raise the temperature of individual catalyst particles by $150\text{--}200^\circ$ for a few seconds [Zhorov *et al.* (2)]. Recently, Wurzbacher (3) has reported high-temperature gradients in a model catalyst pellet for the $H_2\text{--}O_2$ reaction. Several earlier attempts [see references 4–15 in Wurzbacher, ref. (3) of this paper] to estimate the temperature rise in catalyst pellets, however, showed that it was of the order of a few degrees only. Zhorov *et al.* (2) have pointed out the reasons for getting such low and misleading values.

We have measured temperature profiles in a rapidly fouling catalyst bed and have found that they indeed correspond to the prediction of Froment and Bischoff (1). The reaction studied was the air oxidation of hydrogen sulfide over active carbon (activated coconut shell charcoal, 2–4 mm size) as a catalyst:



Here the sulfur formed progressively covers the catalyst surface. The reaction readily takes place even at room temperature. The heat of the reaction (calculated) is 53 kcal/mole and it heats up the catalyst considerably. A glass reactor (Fig. 2), with five thermometers at various depths in the

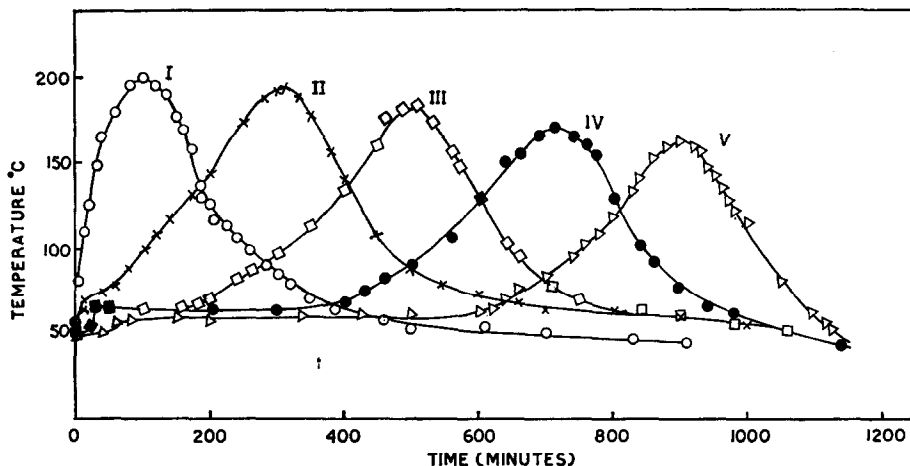


FIG. 3. Temperature profiles shown by the five thermometers for an initial reactor temperature of $50^\circ C$.

TABLE 1
TIME AND TEMPERATURE AT THE MAXIMA INDICATED BY THE FIVE THERMOMETERS
IN THE CATALYST BED^a

Initial temp.	Thermometer									
	I		II		III		IV		V	
	Time	Temp.	Time	Temp.	Time	Temp.	Time	Temp.	Time	Temp.
25°	90	170°	250	153°	375	158°	530	120°	650	94°
50°	100	200°	310	194°	510	183°	710	171°	904	163°
80°	200	218°	460	210°	740	205°	970	200°	1170	178°

^a Distance between two successive thermometers: 2.25 inches. Time in minutes. Temperature in °C.

catalyst bed, was used to follow the temperature maximum advancing along the length of the reactor as a function of time. The gas mixture used was H₂S:air:N₂ 6:15:25 liters/hr. A heating element was wound around the reactor followed by 1-inch thick insulation with asbestos rope. The reactor can be kept at different initial temperatures (26°, 50°, 80°C) with 25 liters/hr of nitrogen flowing through it. The heat input through the heating element was maintained constant during any particular run. With nitrogen flow only, the temperature indicated by thermometers I to V did not differ by more than $\pm 2^\circ$.

The readings of all the five thermometers as a function of time show clear maxima. As a typical example, the results obtained for an initial reactor temperature of 50°C are shown in Fig. 3. The maximum temperatures and the times at which they are attained for different initial reactor temperatures are given in Table 1. The maximum temperatures increase and the times decrease with increasing initial temperature. At any initial temperature, the maximum reached at any thermometer is in general slightly lower than that at the preceding thermometer. This may be due to the fouling of any catalyst layer and

the consequent decrease in surface area of the catalyst being relatively more than that of its preceding layer before the zone of maximum rate and maximum temperature reaches these layers. The sulfur deposited on the catalyst also tends to flow down into the lower layers, especially at higher temperatures. The studies are continuing and a detailed analysis of this problem will follow.

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