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Note

DETERMINATION OF KINETICS AND THERMAL CONDUCTIVITY OF HYDRATES SIMULTANEOUSLY BY USING THERMOGRAVIMETRY AND TRANSIENT HOT STRIP METHOD

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In a previous paper [1], a discussion has been given of the necessity for knowledge of the kinetic properties of a solid–gas reaction in order to be used in a chemical heat pump.

However, a more complete assessment of the suitability of sorbents requires the knowledge of thermal properties and, in particular, of thermal conductivity. As the greatest contribution to the heat transfer in solid particles and between particles is the conduction of heat.

In this communication, we want to present a combination of two different experimental techniques: Thermogravimetry and the Transient Hot Strip in order to study kinetic and thermal conductivity simultaneously. The experimental conditions in which the experiments can be carried out are the same as those prevailing in chemical heat pump application, i.e., a constant temperature and vapour pressure of the working fluid.

The sodium sulphide system was selected to test this new technique because it has recently been investigated by us [2,3] from the point of view of kinetics and mechanisms as well as used in the Tepidus chemical heat pump system [4].

INSTRUMENTATION

Desorption and sorption kinetics are studied by means of thermogravimetry under controlled water vapour pressure according to the cold point

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method [5]. The instrumental set-up is well suited for kinetic experiments in both isothermal and temperature scanning modes.

The thermogravimetry equipment, which consists of a McBain quartz spring balance, is described elsewhere [6–8]. Weight changes are recorded by means of a thermostatted quartz spring suspended in the vertical axis of the apparatus and to which the sample is fixed. The sample temperature may be set from 273–373 K and measured by a thermocouple connected to a twin sample located close to the suspended sample pan. The device includes a continous optical recording of the sample weight.

The thermal conductivity of the salt is measured by using the Transient Hot Strip or THS method recently developed at the Chalmers University of Technology [9]. In this method a flat strip is used both as a continuous plane heat source and as a sensor for the temperature increase in the strip itself. By supplying a constant current to the metal strip (the output of power is then very nearly constant) and by monitoring the subsequent voltage increase over a short period of time after the start of the experiment, it is possible to get precise information on the thermal transport properties of the material surrounding the heat source. The recorded voltage change is originally due to the temperature increase which causes an increase in the electrical resistance of the strip.

In order to combine both techniques a plexiglass sample cell was constructed with a platinum strip which was placed vertically in the sample

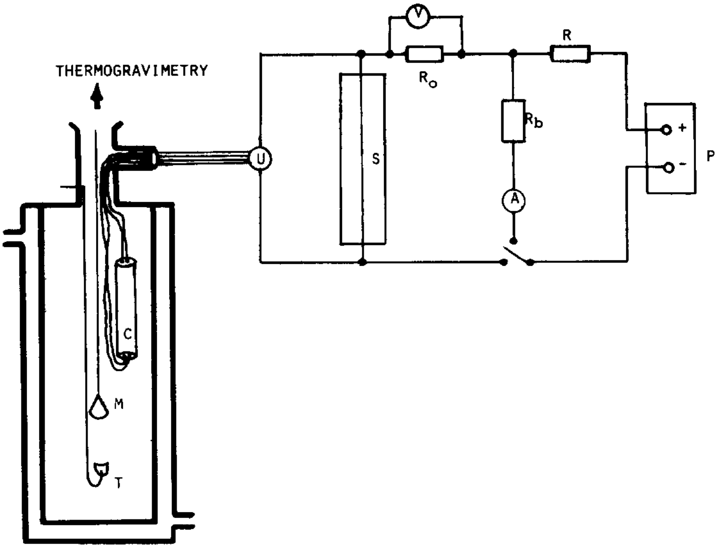

Fig. 1. Thermostatted oven to be connected to the thermogravimetry equipment: M, sample; T, thermocouple; C, cell for the thermal transport studies by the THS technique connected to the electrical circuit: S, P, power supply; R_0, R_b and R, standard resistor, current limiting resistor and balancing resistor, respectively; A, ammeter; U and V digital voltmeters.

space and soldered to the leads. This cell was put into the thermogravimetry reactor and connected to a voltmeter (see Fig. 1).

The thermal conductivity can be measured at different temperatures and water vapour pressure as well as in vacuum, knowing perfectly the water content of the salt by means of the thermogravimetry. The pertinent experimental kinetic and thermal data are conveniently collected and treated by means of a microcomputerized data acquisition system.

MATERIALS

Fresh sodium sulphide 9-hydrate of reagent grade (Merck p.a.) was utilized. The anhydrous sodium sulphide was prepared in a vacuum oven at 343 K, the other hydrates were prepared in situ in the cell placed in the thermogravimetry reactor at 295 K for $Na_2S \cdot 9H_2O$ and 323 K for $Na_2S \cdot 5H_2O$. The water vapour pressure was 8 Torr in both cases.

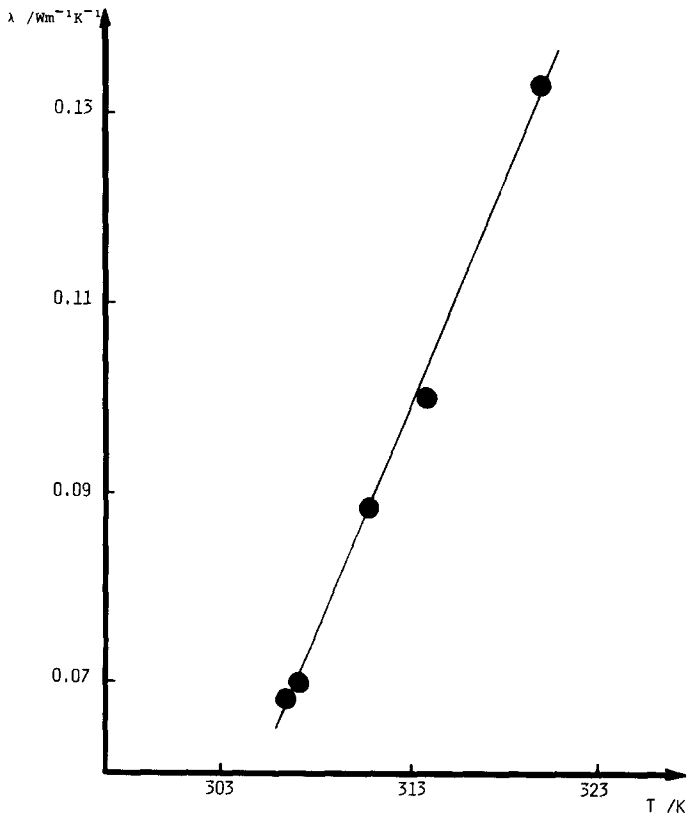

Fig. 2. Thermal conductivity vs. temperature of Na_2S in vacuum.

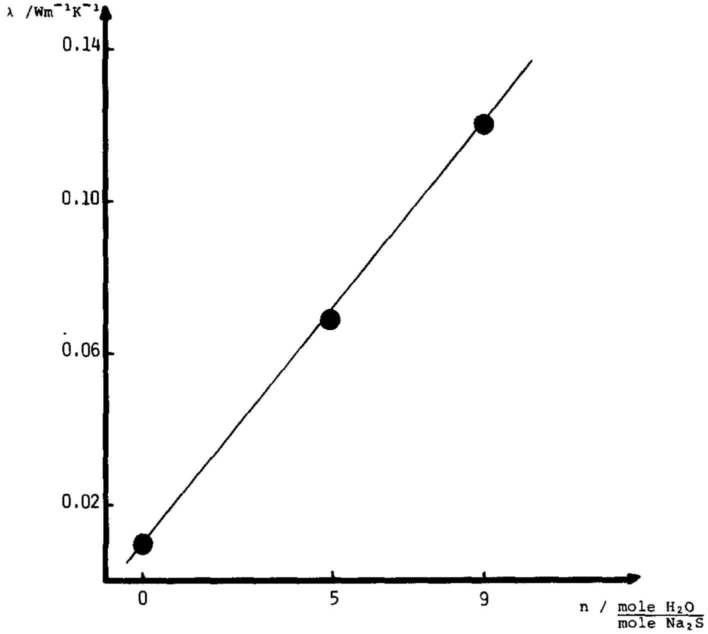

Fig. 3. Thermal conductivity of the sodium sulphide hydrates at 295 K and 8 Torr.

RESULTS

Kinetics results were the same as we had obtained previously [2,3].

Thermal conductivity for Na_2S has been calculated at different temperatures in vacuum, because of its reactivity. Figure 2 shows these results.

In order to study the dependence on the water content of the salt, the thermal conductivity of $Na_2S \cdot 9H_2O$ was calculated at 295 K and 8 Torr and compared to the extrapolated values of Na_2S and $Na_2S \cdot 5H_2O$ under the same conditions. These results are shown in Fig. 3.

This work indicates that it is possible to combine both techniques in order to study kinetic and thermal properties in the same set of experiments.

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