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Data Article

Absorption of ammonia in the melt of nitrogen–Sulphur containing fertilizer

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A R T I C L E I N F O

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A B S T R A C T

The paper deals with the absorption of gaseous ammonia in model fertilizer of ammonium nitrate and ammonium sulphate. Volumetric overall mass transfer coefficient quantitatively characterizing the process was estimated on the basis of experimental data and kinetics modeling. The coefficient depends on the temperature, content of water in the fertilizer and hydrodynamic conditions. Different hydrodynamic conditions were simulated by different speed of the propeller stirrer.

Specifications table

Subject area	*Physical Chemistry, Chemical Engineering, Inorganic Chemistry*
Compounds	Ammonium nitrate, ammonium sulphate
Data category	*Physicochemical*
Data acquisition format	*Volumetric overall mass transfer coefficient depending on the reaction conditions*
Data type	*Raw, analyzed*
Procedure	*Linear regression analysis (least square method)*
Data accessibility	*Data are presented in the article*

1. Rationale

In the past, before introduction of the desulfurization process, SO_2 escaped into the atmosphere and formed acid rains. Paradoxically, acid rains containing sulfur (mainly SO_4^{2-}) have been useful for fertilizing and growing of plants. Today, we need to use, instead of acid rains, sulfur containing fertilizers, e.g. $(NH_4)_2SO_4$, and their combination with other compounds, e.g. NH_4NO_3.

Ammonium nitrate is an important fertilizer. The addition of ammonium sulfate to ammonium nitrate improves its properties, *viz.* it protects this fertilizer against detrimental changes of temperature. Ammonium sulfate can be added as a pure, crystal substance, or it can be formed *in-situ* by the addition of sulfuric acid. In the latter case, nitric acid and ammonium

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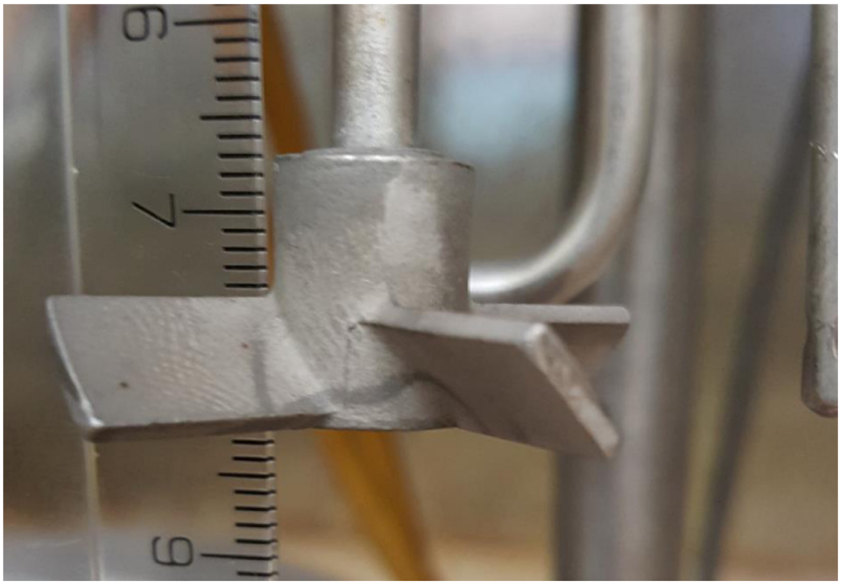

Fig. 1. Detail of the propeller stirrer with the scale.

sulfate are formed by the reaction of sulfuric acid with ammonium nitrate. When dolomite (or limestone) is added to the mixture during granulation of the fertilizer, it reacts with nitric acid under the formation of soluble nitrates of calcium and magnesium. Escaping carbon dioxide makes pores in the fertilizer, which deteriorates quality of the primary product and it also declines its storability. For preserving quality of fertilizer, it is necessary to neutralize formed nitric acid. It is common to make this by the addition of liquid or gaseous ammonia into the molten fertilizer. When gaseous ammonia is used, we need to know (for the design of industrial absorber) parameters characterizing the transfer of ammonia from the gaseous phase into molten (liquid) fertilizer. Crucial parameter characterizing rate of this process is the volumetric overall mass transfer coefficient. This coefficient depends on the properties of fertilizer (including the amount of water content) and on the hydrodynamic conditions in the liquid phase. These data are not available in open literature.

In this paper, we will present data on the process of ammonia absorption into a model fertilizer based on the mixture of ammonium nitrate with sulfuric acid at the temperatures over 110 °C.

2. Procedure

Composition of the model fertilizer was as follows (wt. %): 7.01% H_2O; 25.80% total nitrogen; 16.9% nitrogen in ammonia compounds (NH_4^+); 8.90% nitrogen in nitrate compounds, 9.29% sulphur (water soluble); 1.29% total MgO; 1.01% water soluble MgO. (In fact, it is not a MgO compound. In the fertilizer production area, the magnesium content is usually expressed in the form of MgO.) pH of 10 wt. % water solution was 4.0.

Approximately 100 g of homogenized solidified fertilizer melt was weighed-in a Teflon vessel (inner diameter 55 mm, height 90 mm) and placed into the pressure reactor (Parr 4842, USA). Required amounts of deionized water (and in several experiments also sulfuric acid) were added. The content of water was in the range 7.01 wt. %–9.00 wt. %. The amount of water content was determined by Karl Fischer titration [1]. The reactor was closed and heated up to the temperature of 110 °C. After melting, the propeller stirrer was immersed into the molten fertilizer. Because the stirrer is important from the point of view of hydrodynamic conditions, it is shown in Fig. 1. Speed of mixing was 50, 100, 200, 400 and 600 RPM, which represents the angular frequency 5.24, 10.47, 20.94, 41.89 and 62. 83 rad/s, respectively. Subsequently, the required pressure of ammonia was adjusted (NH_3, quality A2.8, Messer Tatragas) and the changes in pressure and temperature were read as a function of time. (During pressurizing with ammonia gas, the stirrer was not used.) Error in reading of pressure was ± 4 kPa (Measuring unit of the reactor is *psi.*) During the experiment (60 min), dosing of ammonia was repeated several times. After 60 min the experiment was stopped and the molten mixture cooled. Solidified mixture was dissolved in water (making 10 wt. % solution) and pH of the solution was measured (827 pH lab Metrohm).

When the chemical reaction between the gaseous and liquid phases proceeds, the gaseous component has to cross the phase interface before the reaction. Rate of the consumption of the gaseous component depends both on the rate of the reaction in the liquid phase and on the rate of transport of gas through the gas – liquid phase boundary. This process can be described by the film theory [2–5] which assumes formation of gas and liquid films on the opposite sites of the boundary layer. In both films, transport of substances is governed only by the diffusion. If the concentration of reacting components in the gas is high enough, it can be assumed that the transport in the gaseous phase to the gas/liquid phase boundary does not influence the rate of the overall reaction.