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Effect of Ammonium Sulfate-sulfur Mixture on the Diffusivity and Index of Activity of Ammonium Sulfate

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This paper deals with the diffusivity characteristics and the index of activity of ammonium sulfate-sulfur mixture, slow release fertilizer through water. Sulfur used was pure agriculture sulfur as well as sulfur sludge from Abou Zaabal Fertilizer Company. Different practical and theoretical methods were used from which the diffusivity of ammonium sulfate-sulfur mixture through water was found and compared with that of ammonium sulfate fertilizer.

Key words: Slow release fertilizers, Ammonium sulfate fertilizer, Diffusion of ammonium sulfate.

Introduction

This investigation is a part of a study carried out on ammonium sulfate (As)-sulfur (s) mixtures (Chalabi and El Sheltawi 1979; Coulson and Richardson 1983) to determine its suitability for the use as a slow-release fertilizer (Gordon and Barrow 1979; El Sheltawi *et al* 1990).

For the determination of the solubility of slow-release nitrogen two parameters may be defined: the index of activity (I.A.) (Krabave and Margan 1954; Mikkelsen *et al* 1994), and the rate equation (Shahandeh *et al* 1992).

$$I.A\% = \frac{\text{Cold water insoluble nitrogen-hot water insoluble nitrogen}}{\text{Cold water insoluble nitrogen}} \times 100$$

$$= \frac{CWIN - HWIN}{CWIN} \times 100 \quad \text{.....(1)}$$

Rate equation = Fick's first law

Experimental

Materials Used: Ammonium sulfate (As). Ammonium sulfate was fertilizer grade, having 20.5% N_2 supplied by Chemicoke Factory in Tebin, Cairo.

Sulfur (S). Sulfur used was fertilizer grade (m.p.=150°C) supplied by Abu-Zaabal Fertilizer Company.

Sulfur Sludge. Sulfur sludge was a solid waste filter cake obtained by filtration of sulfur melt before oxidation of sulfur (m.p.=159°C) from the Abu-Zaabal Fertilizer Company (Cairo).

Experimental Techniques. Different As-s mixtures of weight ratio (0.025, 0.5, 0.75 and 1) were prepared.

The particle size of As and s was 0.1 cm. As-s mixtures were pelletized using APEX hydraulic presses. Type M1/R. Pellets prepared were of 1.5 cm diameter and 0.4 cm thickness at 150 psi.

Results and Discussion

Diffusivity Measurements. The diffusivity of As-s mixture was determined using two different methods viz. Winckleman's experimental method and empirical equation.

Wincklemans Method (Sibak 1993; Sweeney and Granade 1993; Sibak 1997). In this method a disc of As-s mixture is placed in the bottom of the vertical arm of the apparatus shown in Fig. 1.

Water is passed through the plain tube at constant temperature and with suficient velocity to ensure that the concentration of As-s mixtures at the junction of the two tubes is zero. The concentration at the disc surface equals the saturation concentration.

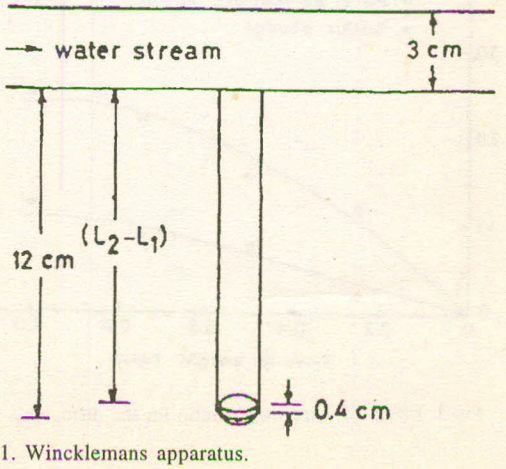

Fig.1. Wincklemans apparatus.

The dissolved As-s mixtures are transferred from the surface of the disc to the water stream by molecular diffusion.

The diffusivity of the fertilizer can be calculated from Fick's first law.

$$Na = \frac{D(C_{A1} - C_{A2})}{(L_2 - L_1)} a \quad \text{.....(2)}$$

Where:

Na = The rate of mass transfer of diffusing fertilizer, g/sec.

(L_2-L_1) = The liquid level, cm

C_{A1} = The concentration of the fertilizer at the disc surface (saturation concentration), g/cm^3.

C_{A2} = The concentration of the liquid stream (approximately zero).

a = The area of the disc assumed constant and equal to cross sectional area of vertical tube, cm^2.

So the diffusivity of As-s mixtures was calculated and results plotted in Fig. 2.

Empirical Equation Method. The diffusivity can also be determined using the following empierical equation (Treybal 1980).

$$D = \frac{7.7\,(10)^{-10}}{\mu_0 (V_A^{1/3} - V_0^{1/3})} \quad \text{..... (3)}$$

Where:

D = Molecular diffusivity, cm^2/sec.

T = Temperature, 298k.

μ_0 = The viscosity of the solvent, 10^{-2} poise.

V_0 = The molecular volume of the solvent, 18 cm^3/g mole.

V_A = The molecular volume of the solute, 132 cm^3/g mole.

By substitution in the empirical equation the diffusivity of pure agriculture sulfur (As) of weight ratio 1 at constant temperature 298k is 34 $(10)^{-8}$ cm^2 sec^{-1}. It has nearly the same value as that of experimental results determined by Winckleman's method, 25.2 $(10)^{-8}$ cm^2/sec as shown above.

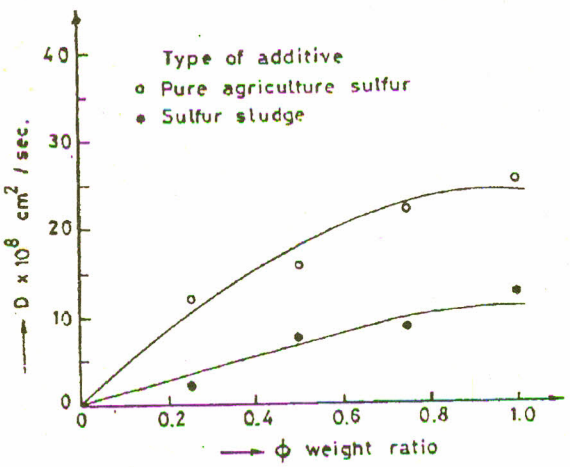

Fig.2. Effect of As/s weight ratio on the diffusivity

Effect of Method of Preparation of As-s Mixture on Diffusivity (Washington 1965).

Where:

the weight ratio of As/s = 0.25

SCAS = sulfur coated ammonium sulfate.

Effect of As/s Weight Ratio on the I.A. of the Fertilizer. The effect of the As-s weight ratio (0.25, 0.50, 0.75 and 1) on the I. A. of As-s mixtures was studied using different types of s (pure agriculture sulfur and sulfur sludge).The results are plotted in Fig. 3, from which it may be observed that the I. A. of As-s mixtures increased by increasing the wt. ratio of As/s and the I. A. of As-s mixtures (pure agriculture sulfur) is higher than As-s mixtures (sulfur sludge).

Conclusions

From the above investigation we may deduce that the sludge obtained from sulfur purification during manufacture of sulfuric acid in fertilizer company may be used as suitable agent for decreasing the nitrogen release of soluble ammonium sulfate fertilizer in the soil, and that its diffusivity is closely comparable with pure sulfur.

This process will provide high benefit to fertilizer consumption and good waste management solution for fertilizer company producing sulfuric acid from sulfur.

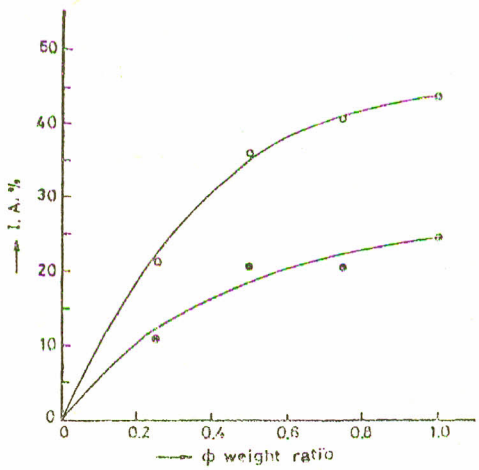

Fig.3. Effect of As/s weight ratio on the I.A.

Table 1

Effect of method of preparation of As-s Mixture on D.

Fertilizer	As	As-s mixture	SCAS
D	$10(10)^{-4}$	$10.2\,(10)^{-8}$	$15\,(10)^{-9}$

The optimum use of such fertilizer in agriculture is As/s wt ratio 0.25 and the particle size of As and s was 0.1cm.

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