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Polythermal Solubility of the Acetic Monoethanolamine-Thiocarbamide-Water System

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ABSTRACT: The $CH_3COOH{\cdot}NH_2C_2H_4OH$ - $CS(NH_2)_2$ - H_2O salt system was studied using visual polythermal solubility analysis at various concentrations over a temperature range from -50.4°C to 6.0°C. A polythermal solubility diagram was constructed based on the results obtained. It highlights the crystallization regions of ice, acetic acid, acetic monoethanolamine, and thiocarbamide. The studied salt system belongs to the simple eutonic type; the initial components retain their individual identities.

KEY WORDS: acetic acid, monoethanolamine acetate, thiourea, solubility, system, polytherm, diagram, concentration.

I.INTRODUCTION

Currently, the demand for agricultural crops is increasing daily. Therefore, one of the most important agricultural practices is ensuring a full, high-quality harvest before the onset of cold autumn days. To achieve this, treating plants with low-toxicity chemicals accelerates their physiological processes, shortens the ripening period, and enables a full harvest in a short time [1, 2]. To ensure the transfer of physiologically active nutrients from the leaves and branches of plants to the fruit, it is necessary to remove leaves or use defoliants containing chemicals that dry out the upper part of the plant [3, 4]. All these measures lead to increased productivity and enable the widespread use of mechanization in harvesting agricultural products.

Ethanolamines and their compounds with acetic [5], citric [6], nitric [7], and phosphoric [8] acids exhibit physiological activity. The presence of the ethylene ($-CH_2-CH_2-$) group in these compounds leads to an increase in the ethylene content in the axillary zone of plant leaves, leaf fall, and an increase in the defoliation process [9,10]. The solubility of acetic systems has previously been studied with monoethanolamine [11], diethanolamine with acids, and triethanolamine [12], and their physiological properties have been confirmed in agrochemical tests [13-14]. Thiocarbamide is a substance with both nutritional and fungicidal properties [15–16]. A group of chemicals used to combat bacterial and fungal diseases of agricultural crops, fungicides are pesticides that destroy plant pathogens, completely or partially inhibiting their development [17].

Taking into account the above considerations, it is advisable to study the interaction of preparations that have both nutritional and physiologically active properties and use them in the composition of chlorate-containing defoliants.

II. METHODOLOGY

Acetic monoethanolamine and thiocarbamide were used in the study. Acetic monoethanolamine was synthesized by reacting acetic acid and monoethanolamine in a 1:1 molar ratio. 98.0% thiocarbamide salt under the trade name "kt" was used [18].

The solubility of the system of vinegar, monoethanolamine, and thiocarbamide was studied using the observational polythermal method. The composition of the liquid and solid phases was determined by quantitative

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analysis methods, nitrogen by the Kjeldahl method [19], and carbon and hydrogen by the Dumas micromethod [20].

III. EXPERIMENTAL RESULTS

The $CH_3COOH{\cdot}NH_2C_2H_4OH$ - $CS(NH_2)_2$ - H_2O system was studied using binary systems and eight internal sections, and a polythermal solubility diagram was constructed in the temperature range from -50.4°C to 6.0°C (Fig. 1). Sections I-IV were studied by transferring $CS(NH_2)_2$ - H_2O to the end $CH_3COOH{\cdot}NH_2C_2H_4OH$, and sections V-VIII were studied by transferring $CH_3COOH{\cdot}NH_2C_2H_4OH$ - H_2O to the end $CS(NH_2)_2$. The diagram highlights the crystallization regions of ice, acetic acid, acetic monoethanolamine, and thiocarbamide. This system belongs to the simple eutonic type, and the components retained their individuality. The diagram of the system shows that thiocarbamide, which has low solubility compared to other components, occupies most of the regions.

Two triple points were detected in the system (Table 1), the first of which corresponds to 53.4% $CH_3COOH{\cdot}NH_2C_2H_4OH$, 2.4% $CS(NH_2)_2$, and 44.2% water at -43.0 °C; the solid phase consists of ice, acetic acid, and thiourea. The second triple point corresponds to 62.2% $CH_3COOH{\cdot}NH_2C_2H_4OH$, 9.0% $CS(NH_2)_2$, and 28.8% water at 3.2 °C; the solid phase consists of acetic monoethanolamine, acetic acid, and thiourea. Solubility isotherms at 10 °C intervals and projections of the polythermal curves onto the aqueous sides of the diagram were also plotted.

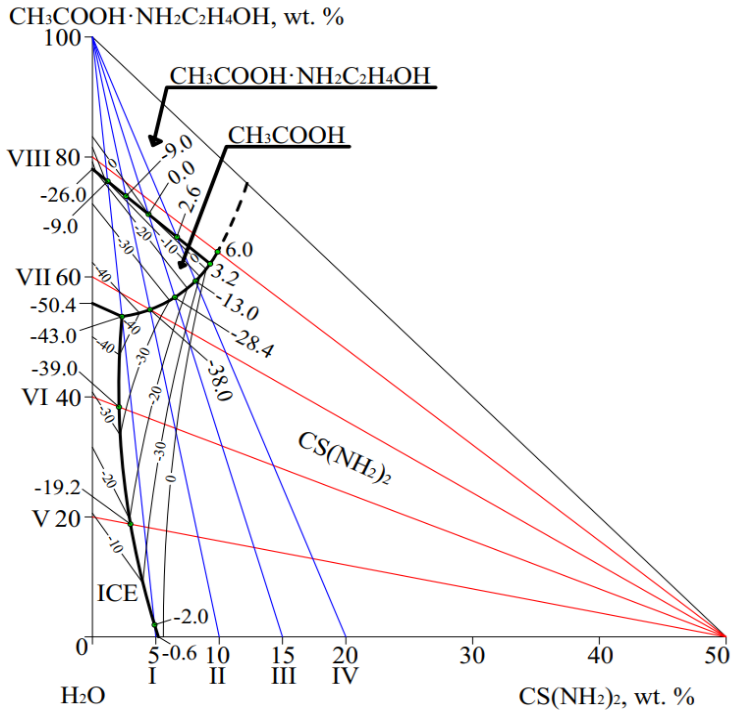

Fig 1: Solubility diagram of the $CH_3COOH{\cdot}NH_2C_2H_4OH$ - $CS(NH_2)_2$ - H_2O system

Table 1. Double and triple points of the system $CH_3COOH{\cdot}NH_2C_2H_4OH$ - $CS(NH_2)_2$ - H_2O

Composition of liquid phase, %			$T_{cr.}$, °C	Solid phase
$CH_3COOH{\cdot}NH_2C_2H_4OH$	$CS(NH_2)_2$	H_2O		
-	5.2	94.8	-0.6	Ice + $CS(NH_2)_2$
1.2	5.0	93.8	-2.0	-//-
18.6	3.0	78.4	-19.2	-//-
38.4	2.2	59.4	-39.0	-//-
53.4	2.4	44.2	-43.0	CH_3COOH + $CS(NH_2)_2$ + Ice
55.6	-	44.4	-50.4	CH_3COOH + Ice
54.2	4.0	41.8	-38.0	CH_3COOH + $CS(NH_2)_2$
57.0	6.8	36.2	-28.4	-//-

60.0	8.0	32.0	-13.0	-//-
62.2	9.0	28.8	3.2	$CH_3COOH·NH_2C_2H_4OH + CH_3COOH + CS(NH_2)_2$
78.0	-	22.0	-26.0	$CH_3COOH + CH_3COOH·NH_2C_2H_4OH$
76.0	1.2	22.8	-9.0	-//-
73.8	2.6	23.6	-3.2	-//-
70.8	4.8	24.4	0.0	-//-
67.0	6.6	26.4	2.6	-//-
64.2	9.7	26.1	6.0	$CH_3COOH·NH_2C_2H_4OH + CS(NH_2)_2$

The table shows that ice cocrystallizes with $CS(NH_2)_2$ in the temperature range from -0.6 °C to -39.0 °C, with CH_3COOH at -50.4 °C, with thiocarbamide CH_3COOH in the temperature range from -38.0 °C to -13.0 °C, with $CH_3COOH·NH_2C_2H_4OH$ at 6.0 °C and with acetic acid $CH_3COOH·NH_2C_2H_4OH$ at -26.0 °C to 2.6 °C. This system belongs to the simple eutonic type, and the components retain their individuality.

IV. CONCLUSION AND FUTURE WORK

The $CH_3COOH·NH_2C_2H_4OH$ - $CS(NH_2)_2$ - H_2O salt system was studied using visual polythermal solubility. A polythermal solubility diagram constructed based on the obtained results limits the crystallization regions of ice, monoethanolamine acetate, acetic acid, and thiourea in the three-component system. The initial substances retain their individual identities, and no new compounds are formed. The studied system belongs to the simple eutonic type, which serves as the scientific basis for the creation of a new defoliant based on $CH_3COOH·NH_2C_2H_4OH$ and $CS(NH_2)_2$ with complex action.

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