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Study of the Rheological Properties of Components in the Magnesium Chlorate - Urea - Thiocarbamide - Water Solution System

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ABSTRACT: Currently, the creation of preparations combining substances with different properties is one of the main tasks of the chemical industry, and the development of simultaneously defoliating and nutritious preparations is relevant. Therefore, in order to obtain a new multifunctional, effective defoliant using local raw materials, it is important to study the changes in the crystallization temperature, viscosity, density, pH of the medium and refractive indices observed in the solution of the system [91% [36% $Mg(ClO_3)_2$ + 9% $MgCl_2$ + 55% H_2O] + 9% $CO(NH_2)_2$] – $CS(NH_2)_2$ with an increase in the number of components in them. Based on the obtained results, a study of the solution system [91% [36% $Mg(ClO_3)_2$ + 9% $MgCl_2$ + 55% H_2O] + 9% $CO(NH_2)_2$] – $CS(NH_2)_2$ was carried out at a temperature of 25°C., "composition–properties" diagrams were constructed and analyzed. The obtained results showed that this salt system belongs to the simple eutonic type; no new compounds are formed.

KEY WORDS: magnesium chlorate, urea, thiourea, "composition–properties", crystallization temperature, viscosity, density, pH, refractive index.

I.INTRODUCTION

One of the important conditions for harvesting cotton successfully and efficiently before the onset of autumn frosts is the use of chemical agents that accelerate ripening, allow rapid harvesting without reducing yield, and are less toxic [1–2]. When effective defoliants with a 'soft' effect are applied, metabolic processes in the plant accelerate, enhancing the transfer of nutrients into the crop [3–4]. At the same time, the use of defoliants reduces the spread of diseases in plants before harvesting, significantly decreasing their development in the following year and helping preserve yield. However, when magnesium chlorate is used as a defoliant, it has a "harsh" effect on cotton, burning unripe bolls and negatively impacting yield [5–6]. The synthesis and application of magnesium chlorate compounds with urea not only mitigate the harsh effect of chlorate but also provide a nutritional effect due to the urea content [7].

To develop and provide a physico-chemical basis for synthesizing highly efficient, inexpensive defoliants with physiological activity from local raw materials, the physico-chemical properties of aqueous systems containing magnesium chlorate, urea, and thiourea salts were studied over a wide range of temperatures and concentrations.

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II. METHODOLOGY

The objects of study were magnesium chlorate, urea, thiourea, and water. Analytical-grade magnesium chlorate and urea were used, while "kt"-grade thiourea with 98.0% purity was employed [8]. The visual-polythermal method [9] was used to determine solubility in the range –30 to +60 °C with a TN-6 glass mercury thermometer and a TL-15 spirit glass thermometer. In the –100 to +20 °C range, density was measured using a pycnometric method [10], viscosity with a VPJ viscometer, pH with a FE 20 METTLER TOLEDO pH meter, and refractive index with a PAL-BX/RI ATAGO refractometer.

III. EXPERIMENTAL RESULTS

To develop and provide a physico-chemical basis for obtaining new physiologically active and multifunctional defoliants, the "composition–properties" diagram of the [91% [36% $Mg(ClO_3)_2$ + 9% $MgCl_2$ + 55% H_2O] + 9% $CO(NH_2)_2$] – $CS(NH_2)_2$ system was constructed at 25 °C. The dependence of solution properties (crystallization temperature, viscosity, density, pH, and refractive index) on component content was studied. The obtained results are presented in Table 1 and illustrated in Figures 1–3.

Table 1.
Physicochemical properties of [91%[36% $Mg(ClO_3)_2$ + 9% $MgCl_2$ + 55% H_2O] + 9% $CO(NH_2)_2$] – $CS(NH_2)_2$ system solutions

Components content, wt %		Density p, g/cm^3	Refractive index, n_D	pH	Viscosity η, мм^2/c	Tc, t, °C
[91% [36% $Mg(ClO_3)_2$ + 9% $MgCl_2$ + 55% H_2O] + 9% $CO(NH_2)_2$]	$CS(NH_2)_2$					
100	-	1.4342	1.4322	6.01	8.670	-10.0
98.99	1.01	1.4332	1.4355	6.15	8.736	-6.2
98.00	2.00	1.4322	1.4356	6.27	8.783	-2.6
97.02	2.98	1.4310	1.4414	6.38	8.82	-0.6
95.97	4.03	1.4297	1.4438	6.47	8.848	3.4
94.99	5.01	1.4282	1.4456	6.53	8.868	5.4
94.00	6.00	1.4271	1.4496	6.62	9.028	15.2
93.01	6.99	1.4257	1.4530	6.69	9.168	22.2
92.02	7.98	1.4238	1.4562	6.76	9.296	28.4
90.97	9.03	1.4216	1.4587	6.83	9.404	32.0
90.00	10.00	1.4192	1.4605	6.88	9.492	39.0

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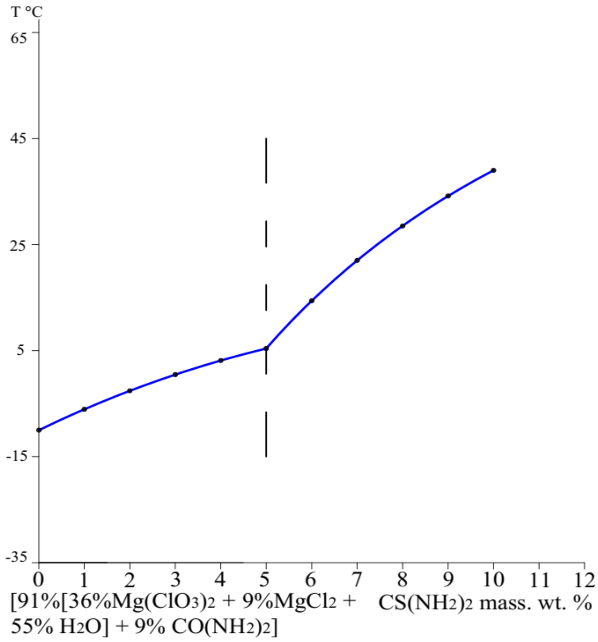
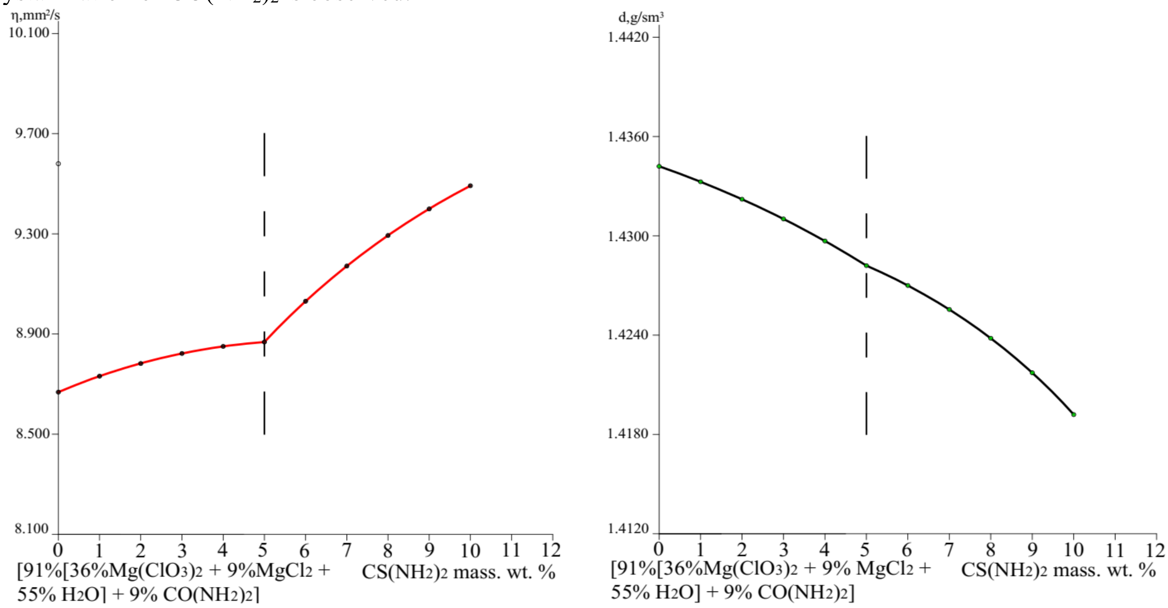


Fig 1. *Crystallization temperature diagram for the [91% [36% $Mg(ClO_3)_2$ + 9% $MgCl_2$ + 55% H_2O] + 9% $CO(NH_2)_2$] – $CS(NH_2)_2$ system*

The crystallization temperature curve (Fig. 1) shows that up to 5.01% thiourea, the crystallization temperature increases to 5.4 °C, corresponding to the ice crystallization field. At higher thiourea content (5.4–39.0 °C), crystallization of $CO(NH_2)_2$ is observed.



A **B**

Fig 2. *A-viscosity and B - density diagrams of the [91% [36% $Mg(ClO_3)_2$ + 9% $MgCl_2$ + 55% H_2O] + 9% $CO(NH_2)_2$] – $CS(NH_2)_2$ system at 25°C*

The viscosity diagram (Fig. 2A) indicates that adding thiourea increases viscosity from 8.670 to 9.492 mm²/s, with a breakpoint at 5.01% thiourea. This corresponds to transitions between ice and urea crystallization regions.

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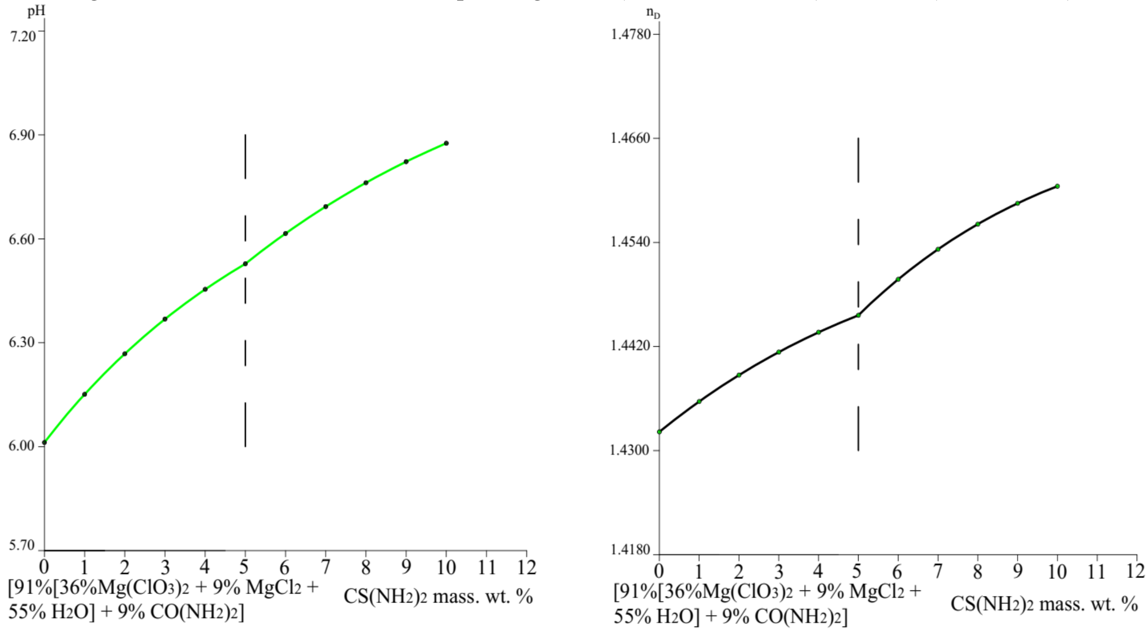
The density diagram (Fig. 2B) shows a decrease in solution density from 1.4342 to 1.4192 g/cm³ with increasing thiourea, again with two distinct fields corresponding to ice (0–5.01% thiourea) and urea (5.01–10.0%).



A **B**

Fig 3. *A-pH and B – refractive index diagrams of the [91% [36% $Mg(ClO_3)_2$ + 9% $MgCl_2$ + 55% H_2O] + 9% $CO(NH_2)_2$] – $CS(NH_2)_2$ system at 25°C*

The pH diagram (Fig. 3A) shows that with increasing thiourea concentration, pH increases from 6.01 to 6.88, with fields corresponding to ice and urea. The refractive index diagram (Fig. 3B) shows refractive index increasing from 1.4322 to 1.4605 with thiourea addition.

IV. CONCLUSION AND FUTURE WORK

The [91% [36% $Mg(ClO_3)_2$ + 9% $MgCl_2$ + 55% H_2O] + 9% $CO(NH_2)_2$] – $CS(NH_2)_2$ system was studied, and composition–property diagrams were constructed. The results show that new defoliants based on magnesium chlorate, urea, and thiourea can be obtained. The diagrams revealed two distinct regions, confirming that the system belongs to the simple eutonic type. The obtained values of component interactions provide information about salt solubility and form a physico-chemical basis for developing new technologies for physiologically active defoliants.

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