STUDY OF DENSITY AND VISCOSITY PROPERTIES OF UREA-SULFATE-NITRATE LIQUIDS

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Currently, many countries that produce ammonium nitrate (AN) are conducting scientific research to identify additives—acting as modifiers—that offer high agrochemical efficiency and improve the product's consumer-relevant properties. In this context, it is necessary to establish a scientific and technical basis for producing non-caking, thermally stabilized AN. This involves several key approaches: creating crystallization centers by incorporating new, highly effective additives (in optimal proportions) into the AN melt, which fill the pores and micro-cracks within the granules and result in a superior surface and internal structure; investigating how these selected additives enhance granule strength and increase the initial decomposition temperature, while simultaneously reducing caking, porosity, and explosive potential; and developing a technology to produce thermally stabilized AN that possesses excellent physicochemical, commercial, and agrochemical characteristics. The rheological properties of modified ammonium nitrate (AN) samples—produced by incorporating finely ground ammonium sulfate ($(NH_4)_2SO_4$) powder into an ammonium nitrate melt—as well as those of sulfate-nitrate melts and sulfate-urea-nitrate melts (derived from NH_4NO_3, $(NH_4)_2SO_4$, and $(NH_2)_2CO$), were determined.

The results are presented in Tables 1–3.

According to Table 1, for sulfate-nitrate melts with a weight ratio of NH_4NO_3 to $(NH_4)_2SO_4$ ranging from (99.5–95) to (0.5–5), the density and viscosity at 170°C were found to be 1.466–1.577 g/cm³ and 6.65–7.47 cP, respectively; at 185°C, the density and viscosity were likewise 1.466–1.577 g/cm³ and 6.65–7.47 cP. In another variant,

urea-sulfate-nitrate melts—produced by adding ammonium sulfate and urea powder to an NH_4NO_3-based composition in the proportions (99.5–95): (0.5–5): (0.5–5)—exhibited a density of 1.514–1.568 g/cm³ and a viscosity of 9.10–9.62 cP at 165°C.

Table 1

Rheological properties of NH_4NO_3 slurry and sulfate-nitrate slurry obtained based on $(NH_4)_2SO_4$

NH_4NO_3 : $(NH_4)_2SO_4$	Density (g/cm³) as a function of the temperature range 170–185°C				Viscosity, depending on the temperature range 170-185°C, (cПз)			
	170	175	180	185	170	175	180	185
99,5 : 0,5	1,466	1,463	1,460	1,453	6,65	6,12	5,57	5,11
99,0 : 1,0	1,472	1,471	1,475	1,467	6,72	6,25	5,74	5,23
98,5 : 1,5	1,485	1,485	1,481	1,474	6,74	6,34	5,85	5,42
98,0 : 2,0	1,493	1,494	1,497	1,482	6,81	6,49	6,06	5,59
97,5 : 2,5	1,511	1,507	1,502	1,491	6,99	6,63	6,12	5,75
97,0 : 3,0	1,520	1,512	1,513	1,495	7,06	6,71	6,36	5,83
96,5 : 3,5	1,534	1,524	1,519	1,506	7,21	6,92	6,42	6,04
96,0 : 4,0	1,546	1,538	1,524	1,518	7,33	7,16	6,64	6,22
95,5 : 4,5	1,552	1,545	1,534	1,525	7,39	7,10	6,75	6,38
95,0 : 5,0	1,577	1,556	1,548	1,527	7,47	7,21	7,09	6,72

Table 2

Density of urea-sulfate-nitrate solutions based on NH_4NO_3 solution, $(NH_4)_2SO_4$ and $(NH_2)_2CO$

NH_4NO_3 : $(NH_4)_2SO_4$: $(NH_2)_2CO$)	Melt density (g/cm³) as a function of the temperature range 160–180°C				
	160	165	170	175	180
99,0 : 0,5 : 0,5	–	1,514	1,492	1,447	1,428
98,0 : 1,0 : 1,0	–	1,521	1,503	1,459	1,437
97,0 : 1,5 : 1,5	–	1,527	1,515	1,470	1,449
96,0 : 2,0 : 2,0	–	1,534	1,523	1,485	1,460
95,0 : 2,5 : 2,5	–	1,543	1,531	1,489	1,472
94,0 : 3,0 : 3,0	1,552	1,547	1,514	1,492	1,485
93,0 : 3,5 : 3,5	1,556	1,551	1,523	1,511	1,503
92,0 : 4,0 : 4,0	1,562	1,556	1,535	1,523	1,516
91,0 : 4,5 : 4,5	1,567	1,561	1,547	1,532	1,523
90,0 : 5,0 : 5,0	1,579	1,568	1,556	1,543	1,531

Table 3

Viscosity of urea-sulfate-nitrate liquids obtained on the basis of NH4NO3 liquid, $(NH_4)_2SO_4$ and $(NH_2)_2CO$

NH_4NO_3 : $(NH_4)_2SO_4$: $(NH_2)_2CO$)	Liquid viscosity (cPz) depending on the temperature range of 160-180ºC				
	160	165	170	175	180
99,0 : 0,5 : 0,5	–	9,10	8,82	8,53	8,25
98,0 : 1,0 : 1,0	–	9,16	8,89	8,62	8,48
97,0 : 1,5 : 1,5	–	9,22	8,96	8,71	8,62
96,0 : 2,0 : 2,0	–	9,27	9,05	8,82	8,76
95,0 : 2,5 : 2,5	–	9,33	9,12	8,91	8,83
94,0 : 3,0 : 3,0	9,88	9,39	9,18	9,02	9,11
93,0 : 3,5 : 3,5	9,74	9,44	9,25	9,09	–
92,0 : 4,0 : 4,0	9,79	9,51	9,32	9,18	–
91,0 : 4,5 : 4,5	9,83	9,57	9,39	9,28	–
90,0 : 5,0 : 5,0	9,92	9,62	9,46	9,37	–

At a temperature of 175°C, the density of the urea-sulfate-nitrate melt ranged from 1.514 to 1.568 g/cm³, and its viscosity ranged from 9.10 to 9.62 cP. Thus, sulfate-nitrate and urea-sulfate-nitrate melts—which contain two nutrient elements—can be granulated without technical difficulties using methods such as intensive mixing or spraying.

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