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DSC INVESTIGATIONS ON THE UREA-ETHANOL-WATER SYSTEM WITH REGARD TO DE-ICING

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ABSTRACT

Melting of urea-ethanol-water mixtures was studied with DSC. Both urea and ethanol content of the samples were below 20%. The results show that the temperature range of application of urea de-icing can be extended by adding ethanol. The action of the melting agents on the surface of ice was modelled in a specially designed DTA cell. A new technology of de-icing was worked out on the basis of the results.

INTRODUCTION

Fast, efficient and non-corrosive removal of ice layers formed on highway junctions, bridges, airport runways etc. is a frequent and important task. Among chemical agents for de-icing, urea was found most suitable [1], but its applicability is limited to temperatures above -8°C. This range was extended by means of solutions of urea in propylene glycol. This mixture, however, renders the special concrete surfaces slippery, and the expenses of its use are three times higher than that of urea [2]. Urea-ethanol /denaturated alcohol/ mixtures offered another possibility of efficient de-icing.

EXPERIMENTAL

More than thirty samples of different, practically important composition were prepared from water, urea and/or ethanol. Du Pont 910 DSC cell was used to study the melting process. The cell containing 7.5-8.0 mg mixture in a sealed sample holder was first undercooled, than the DSC curves were recorded from -25°C with 5°C/min.

The effect of the melting agent at the surface of the ice was modelled in a DTA apparatus whose scheme is shown in Fig.1. Heat transport to the sample holders was facilitated by aluminium powder and copper tubes. The temperature of the block was maintained by a fluid coolant. In the experiments, equal amounts of water were placed in the two sample holder and the block was cooled to the chosen temperature. Then, after freezing and temperature stabilization, the proper amount of urea and/or ethanol was fed into the right hand

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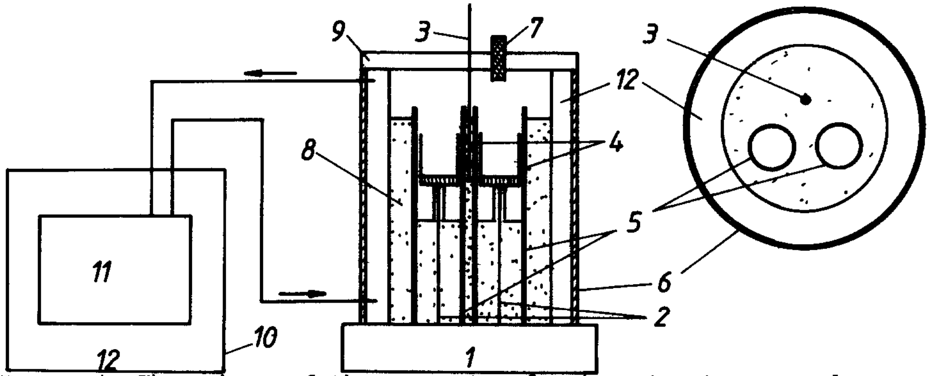

Figure 1. The scheme of the apparatus for investigations on de-icing 1-DTA cell; 2- thermocouples; 3- thermometer; 4- Pt sample holders; 5- copper tubes; 6- insulation; 7- feeding hole; 8- Al powder; 9- cower; 10- Dewar vessel; 11- pump; 12- coolant.

sample holder, and the difference between the temperatures of the two sample holders was recorded as a function of time. Melting mixtures of different composition and amount were added to ice layers of 1,2,...5 mm thickness.

RESULTS AND DISCUSSION

Fig.2 contains five characteristic DSC curves, the peak temperatures of samples containing both urea and ethanol are summarized in Table 1. The -9 °C peak of curve 1 in Fig.2 corresponds to the fusion of urea-water eutectic /with 32,2% urea in the eutectic of -115°C m.p./, the -3°C peak belongs to the dissolution of water in excess of the eutectic composition. In the case of curves 2-4 the total amount of melting agents was nearly identical, the urea/ethanol ratio was changed. Curves 2 and 3 contain eutectic melting peaks at temperatures much lower than curve 1. If the urea/ethanol mass ratio is near 1:1, the peak temperature of this eutectic is between -15.5 and -17°C /see the data of samples 1-10 in Table 1/. The melting point of the pure eutectic is -21°C, the eutectic composition lies outside the range of the present studies. Using larger amounts of ethanol /samples 11-13 in Table 1, curve 4 of Fig.2/ eutectic melting peaks were not observed above -25°C. A considerable amount of the ice is dissolved by the ethanol below this temperature. This process is shown by curve 5 of Fig.2 belonging to an ethanol-water mixture. The considerable differences of the areas under curves 1 and 2-5 is caused by the exotherm heat of mixing of water and

Sample no.	Comp., %		DSC peak temp. °C		Sample no.	Comp., %		DSC peak temp. °C	
	urea	EtOH				urea	EtOH		
1	3,4	3,4	-16	0,5	9	16,9	16,1	-17	-13
2	5,9	5,7	-17	-2	10	17,7	17,6	-16	-14
3	8,2	8,0	-16,5	-3,5	11	3,1	11,0	-	- 3,5
4	10,2	10,0	-15,5	-6	12	9,2	19,4	-	-10,5
5	12,1	12,1	-17	-7,5	13	9,6	15,5	-	-10
6	13,3	13,0	-17	-9	14	15,8	9,6	-16	- 9
7	14,9	14,6	-15,5	-9,5	15	19,6	9,1	-13	- 9
8	16,0	15,4	-16,5	-11	16	11,1	2,8	-13	- 4

Table 1. DSC melting peak temperatures of urea-ethanol-water samples

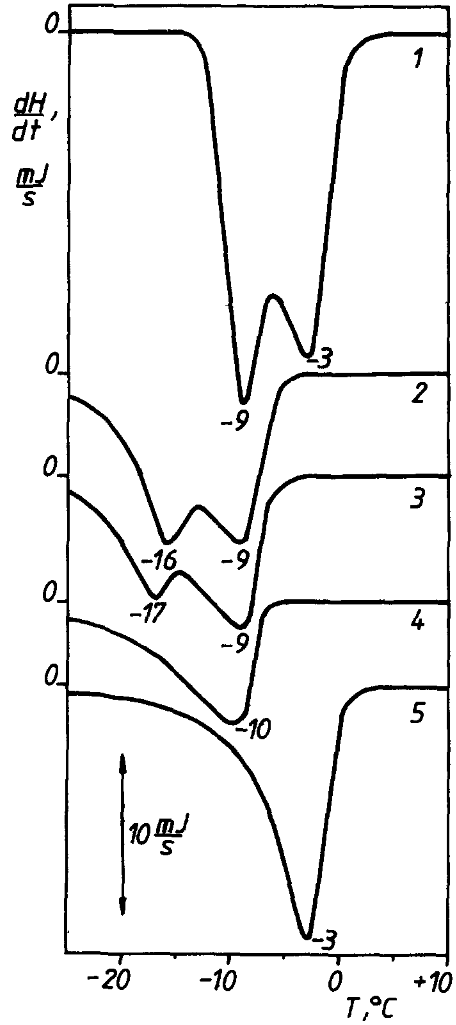

Figure 2. DSC curves of urea/1-13.3%, 2 15.8%; 3-13.3%; 4-9.6%; 5-0%/ -ethanol/1-0%; 2-9.6%; 3-13.0%; 4-15.6%; 5-13.8%/ - water systems

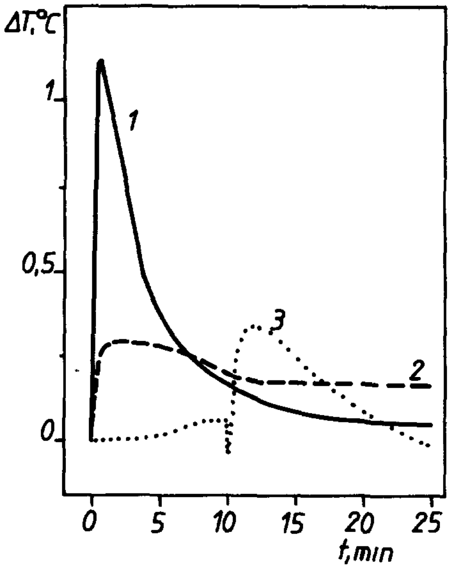

Figure 3. Melting of a 1 mm thick ice layer /95 mg/. 1-6.7 mg urea powder, -2°C; 2-25,3 mg urea powder, -9°C; 3-27.4 mg urea powder at t=o and 24.0 mg EtOH at t=10 min, -10°C

ethanol /being useful from the aspect of de-icing/.

Three of the curves measured with the DTA apparatus /shown in Fig.1/ are demonstrated by Fig.3. The curves characterize the beginning and the rate of the melting process and the extent of undercooling. Curve 3 shows that urea only had a slight effect at -10°C, however, adding some ethanol /of -10°C/ at the tenth minute of the experiment brought about a sudden beginning of dissolution with a practically suitable rate. The applicability of the urea--ethanol system at lower temperatures was conformed by an experiment when nearly two thirds of a 3 mm thick ice layer was melted at -15°C in 30 minutes.

It should be pointed out that de-icing usually does not require complete dissolution. Partial melting and loosening of the layer is satisfactory, final removal may be done mechanically /etc with brushes/. From this point of view, the simultaneous use of urea and alcohol seems advantageous as ethanol diminishes the ice thickness uniformly, while urea was found to form cavities down to the bottom of the sample holder, in the first 10-20 minutes.

On the basis of the results outlined here, a new de-icing procedure has been worked out [3]. Further studies are underway to establish the exact phase diagram of the ternary system in question.

REFERENCES

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