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INFLUENCE OF CONDITIONS FOR OBTAINING STYRENE COPOLYMERS ON PAPER PROPERTIES

The influence of the conditions for obtaining reinforcing additives based on copolymers of styrene and maleic anhydride on change of the physical and mechanical properties of paper is established. The obtained products are completely soluble in water and have an anionic character. Greater anion character has partially saponified sample. The results of thermogravimetric analysis showed that the greater resistance to thermo-chemical degradation has a saponified sample. In this case, activation energy is 177.2 kJ/mol.

Introduction. The growing tendency of recycled fiber use in paper composition necessitates the development and application of new highly effective chemical excipients (adjuvant substances) for paper mass composition to strengthen the wide range of products. Such substances are widely presented in the modern market now and are characterized by various efficiency of action but in some cases the achieved increase and stabilization of physical-mechanical properties remain obviously insufficient.

Possibility of new substances application on the basis of styrene copolymers and maleic anhydride in paper composition is caused by the requirement for high solubility of the received products in water on the one hand, and the efficiency of their strengthening action in combination with other process chemicals on the other. Therefore the purpose of this work is to determine the influence of conditions for obtaining studied substances on efficiency of their strengthening action.

Main part. Researchers in the laboratory of a catalysis of polymerization processes at Research Institute for Physical Chemical Problems of the Belarusian State University have received new adjuvant chemicals i.e. styrene copolymers and maleic anhydride.

One of the requirements giving possibility to use such additives in paper manufacture is their ability to be dissolved in water. Solubility increase of the received products is possible by their saponification, for example by alkali (NaOH). Considering these aspects, the researchers of Research Institute for Physical Chemical Problems of the Belarusian State University have synthesized samples of the additives which differ in degree of saponification of the received copolymers. Their characteristic is presented in the table.

Conditions of synthesis caused receiving additives of the anion character, their structural formula being presented in Fig. 1. The received substances were completely soluble in water and had pH of 7.84 and 8.56 respectively, and were used in the form of the 1% water solutions dosed in sized paper mass. It should be noted that partially saponified sample has bigger anion character.

Characteristic of tested styrene copolymers and maleic anhydride samples

The name of sample	Modifying agent	*n*NaOH / *n*ROH	Molecular mass (M_n)	Ratio of average number (M_n) to average weight (M_w) molecular mass, M_n / M_w	Content of maleic anhydride, mol. %
sample No. 1	NaOH	1/3	5500	1,6	19
sample No. 2		1/1			

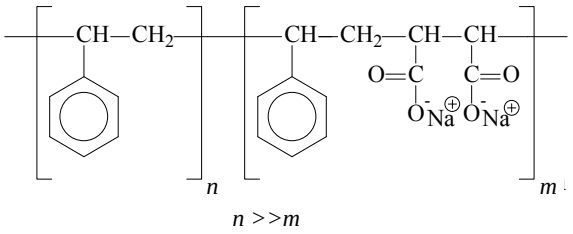

Fig. 1. Structural formula of tested of styrene copolymers

The thermal gravimetric analysis of studied samples has been made to estimate the influence of saponification conditions of the received products on their properties. From the obtained data (Fig. 2–3) it is clear that thermo-oxidative destruction of studied copolymers happens in steps in process of temperature increase. The process proceeds with heat absorption, i.e. it is endothermic.

The received results testify to various compositions of the studied additives, differing in saponification degree of the received products.

Fig. 2 and 3, accurately demonstrate three peaks on the curve characterizing speed of weight loss.

The first peak, rather insignificant, is caused by evaporation of residual moisture in samples and by destruction of low-molecular fractions of copolymer. The area of the second peak, most likely, is connected with destruction of a styrene part of a polymeric chain while the third peak characterizes destruction of blocks of styrene – maleic anhydride. And temperature of destruction of a styrene chain for partially saponified sample is slightly shifted to lower temperatures (T=289.9°C), and direct destruction of styrene – maleic anhydride blocks happens at a temperature of 345.7 and 368.3°C for partially and completely saponified samples of additives respectively. The analysis of the received results of the thermal gravimetric analysis (Fig. 2 and 3) showed essential distinction in structure of received products.

Key parameter of the thermal gravimetric analysis is activation energy of thermochemical destruction (E.D) which was determined by Broydo's method. This method being modified for polymers by N. R. Prokopchuk [1]. Thus, the necessary activation energy to start destruction of a styrene chain of studied additives, for partially and completely saponified samples is 88,2 and 86,6 kJ/mol respectively.

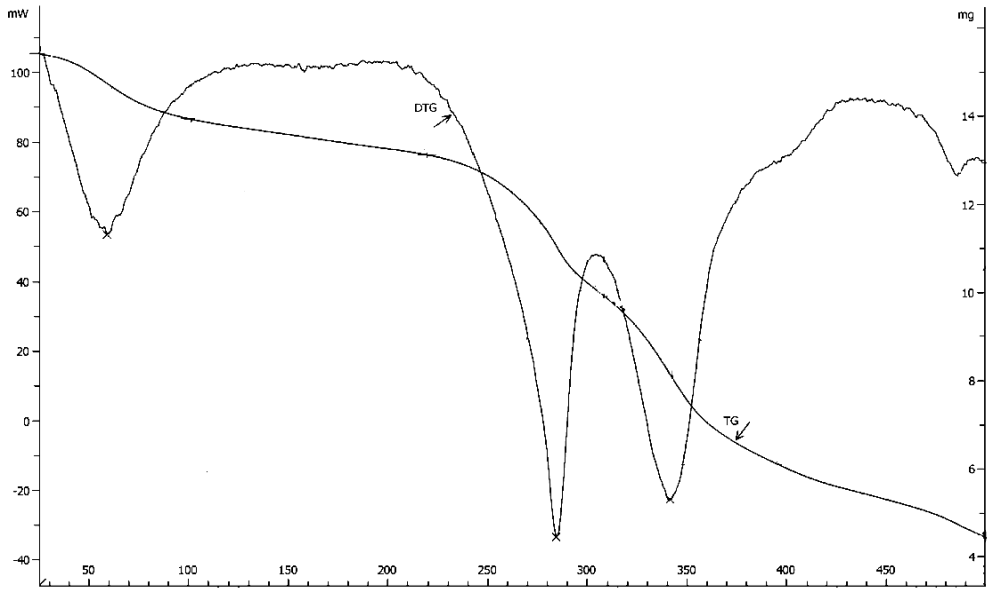

Fig. 2. Thermogram of the studied sample of additive No. 1

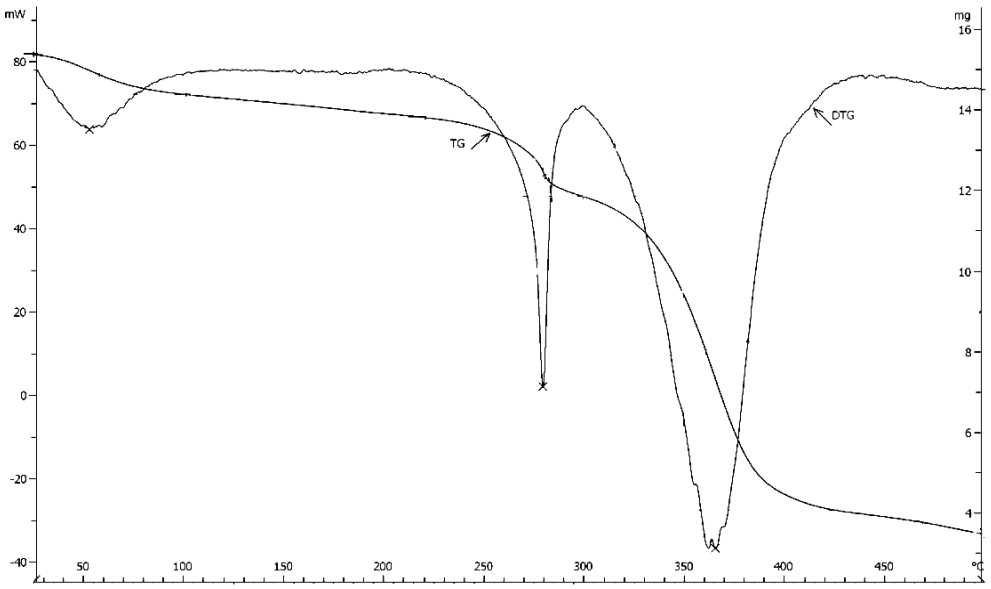

Fig. 3. Thermogram of studied sample of additive No. 2

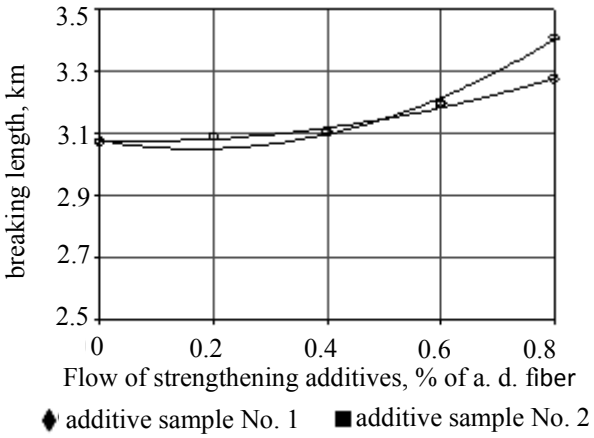

Fig. 4. Change of breaking length of paper samples depending on a type of a strengthening additive

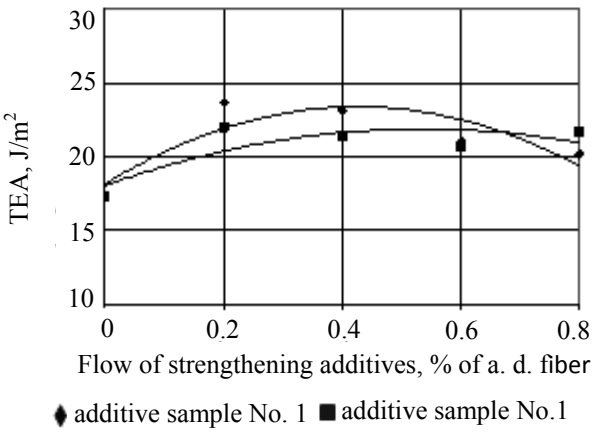

Fig. 5. Tensile energy absorption change of paper samples in dependence upon a type of a strengthening additive

Energy of 92.6 and 117.2 kJ/mol is necessary for destruction of blocks styrene – maleic anhydride respectively.

For an assessment of the received additives influence on physical-mechanical properties of paper there were made paper samples of 100% waste paper (freeness 40°ShR). Paper pulp contained cationic starch in combination with sizing substance on the basis of AKD. The received results of breaking length change and tensile energy absorption (TEA) of paper samples are given in Fig. 4 and 5.

The presented data show that the nature of breaking length change and tensile energy absorption change for both studied samples of additives coincides. However a little bigger effect is reached when using partially saponified sample in composition of paper pulp that probably is connected with its higher electronegative charge.

Conclusion. Thus, influence of conditions for receiving strengthening additives based on styrene and maleic anhydride copolymers upon change of paper physical-mechanical properties has been established. Besides, it should be noted that degree of saponification of the received copolymers influences thermal stability of strengthening additives.

References

1. Прокопчук, Н. Р. Определение энергии акztивации деструкции полимеров по данным термогравиметрии / Н. Р. Прокопчук // Пластические массы. – 1983. – № 10. – С. 24–25.

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