Structural foams based on imide-containing polymers

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Keywords: structural foams, cross-linked polyvinyl chloride, isocyanate, poly(meth)acrylamide, (met)acrylic copolymer particles, strength and thermal properties

Relevance of the research. Poly(meth)acrylamide (P(M)I) and rigid cross-linked polyvinyl chloride (c-PVC) structural foams are widely used as a lightweight core material for sandwich structure composites for aerospace, wind energy, marine and automotive industries because of their high strength, stiffness and heat distortion temperature combined with low density.

Industrial ROHACELL® (Germany) and Acrimid® (Russia) P(M)I foams are produced by thermal treatment of bulk copolymers of (meth)acrylonitrile ((M)AN) and methacrylic acid (MAA). Thanks to the content hexatomic imide rings in the main chains, the PMI foams exhibit excellent mechanical properties and high heat resistance (the maximum operating temperature is 220 °C). However, only P(M)I foam sheets with limited thickness can be prepared by bulk polymerization, which makes it difficult to use such a material in the manufacture of large products. This problem can be solved by using copolymer particles.

c-PVC foams are produced by modification of PVC matrix with various reactive compounds. Divinylcell® (Sweden) c-PVC foam exhibit the maximum operating temperature of 90 °C, while the Russian material exhibit the maximum operating temperature of 60 °C and worse strength properties. This problem can be solved by modification of PVC matrix with various fragments with high heat resistance, for example, imides.

The purpose of the research is to develop the scientific and technical foundation for production of imide-containing foams based on PVC and AN-MAA copolymers.

Tasks:

1. Study of the effect of the type and concentration of reactive isocyanates on strength and thermal properties of PVC-based foams.

2. Study of the effect of the concentration of the foaming agent azobisisobutyronitrile (AIBN) on the physical and mechanical properties of PVC-based foam.

3. Research of the blowing kinetics of AN-MAA copolymer particles. Study of the effect of the conditions of the heat treatment process of copolymers on the formation of the polymer material structure.

4. Study of the effect of the method of forming a cellular structure by foaming AN-MAA copolymer particles on the morphology, physical, mechanical and thermal properties of P(M)I foams.

Scientific novelty:

1. For the first time, the effect of the type and concentration of reactive isocyanates on strength and thermal properties of PVC-based foams was shown.

2. The formation of fragments of urethonimines and imides in the polymer matrix of foams based on PVC and isocyanates was determined by IR spectroscopy.

3. The effect of the foaming agent (AIBN) on the physical and mechanical properties of the foam was determined.

4. P(M)I foams based on AN-MAA copolymer particles were obtained and described. The effect of the foam production method on their morphology and physical and mechanical properties was determined.

5. For the first time, the effect of heat treatment of AN-MAA copolymer particles on the foaming process and the formation of P(M)I foams structure was shown.

Theoretical and practical significance of the research. The necessary conditions for the production of PVC foams with high thermal properties were developed. Optimal conditions for the heat treatment of AN-MAA copolymer particles for the production of P(M)I foams with a density from 60 to 170 kg/m^3 were determined. Complex-shaped foam parts without machining and gluing processes were obtained using the technology of foaming (met)acrylic copolymer particles. Based on experimental data, a method for determining the expansion ratio for foams based on (met)acrylic copolymer particles was proposed. The data obtained in this work is very important for the development of structural foams with high thermal stability.

Provisions submitted for defense:

1. The effect of the type of reactive isocyanates on the formation of a polymer matrix of PVC-based foams.

2. Synthesis of P(M)I foams based on AN-MAA copolymer particles.

3. The effect of the conditions of the heat treatment process on the foaming process, the formation of cellular and chemical structures of foams based on AN-MAA copolymer particles.

4. Research of the strength and thermal properties of the obtained foams.