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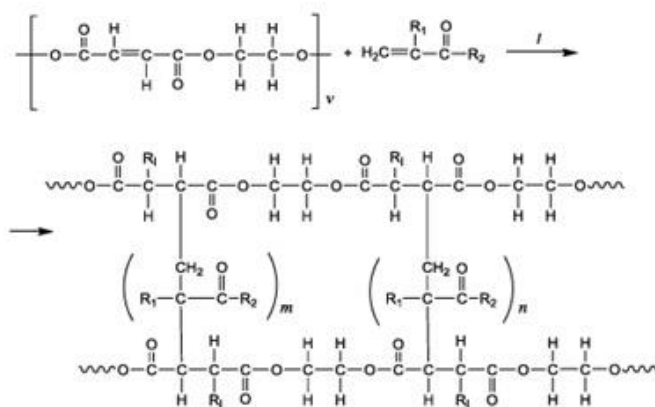
## INVESTIGATION OF THE INFLUENCE OF UV-IRRADIATION ON THERMAL STABILITY OF BINARY SYSTEMS ON THE BASIS OF UNSATURATED POLYESTER WITH SOME VINYL MONOMERS

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The problem of polymer aging under environmental factors is highly relevant [1,2], since changes in the chemical structure and physical properties of polymer materials significantly affect their reliability and service life. In particular, sealing materials (sealants) play a crucial role in construction and technology as they ensure waterproofing, vapor resistance, thermal insulation, and structural durability under varying external conditions. Unsaturated polyesters, including polyethylene glycol fumarate, are considered promising components for sealants due to their reactivity, low cost, and good compatibility with fillers and pigments. However, their long-term stability under UV irradiation remains insufficiently studied [3,4,5].

The aim of this work was to evaluate the influence of continuous UV irradiation on the physical state and thermal stability of binary copolymer systems based on p-EGF with the selected vinyl monomers. For this purpose, p-EGF was synthesized by condensation polymerization of ethylene glycol with fumaric acid in the presence of aluminum chloride as a catalyst [6,7].

The binary copolymers of p-EGF with acrylic acid (AA), methacrylic acid (MAA), and acrylamide (AAM) were synthesized in a carefully selected mass ratio of approximately 35:65 (polyester to monomer). The copolymerization process was carried out via a radical mechanism under so-called “cold” curing conditions, which ensured the possibility of polymer formation at room temperature without the need for additional thermal input. To initiate the radical reaction, a binary initiator system was employed, consisting of benzoyl peroxide (BP) as the initiator and dimethylaniline (DMA) as the promoter. This system provided effective generation of free radicals under mild conditions and thus allowed for controlled polymerization. Schematically the synthesis of the copolymers of p-EGF with AA, MAA and AAM is presented in Figure 1.



where R<sub>1</sub> — H, CH<sub>3</sub> groups; R<sub>2</sub> — H, NH<sub>2</sub> groups; R<sub>1</sub> — the radical of initiator

Figure 1. The scheme of polymerization of p-EGF with the monomers of vinyl row

The choice of the 35:65 ratio was not accidental but rather the result of previous rheological studies that examined the viscosity, density, gelation time, and curing time of various compositions. These studies demonstrated that an increase in the proportion of p-EGF led to a significant rise in both viscosity and density of the mixtures, accompanied by a considerable extension of gelation and curing times. Consequently, the 35:65 ratio represented a compromise that ensured acceptable processability of the system while still retaining sufficient reactivity and desirable mechanical properties after curing.

Identification and characterization of the synthesized copolymers were performed using infrared (IR) spectroscopy. The IR spectra provided confirmation of the chemical structure of the obtained materials, showing characteristic absorption bands corresponding to the functional groups of the initial components and the newly formed copolymer chains. In particular, the spectra revealed the presence of carboxyl and amide groups, as well as methylene vibrations, which served as evidence of successful incorporation of the vinyl monomers into the copolymer backbone. Additionally, signals corresponding to partially unreacted unsaturated double bonds of p-EGF were detected, which confirmed incomplete consumption of all reactive centers during polymerization. The presence of these bonds is of practical importance, as they may participate in further crosslinking reactions during aging or under the influence of irradiation, thereby affecting the final properties of the material.

The obtained samples were then subjected to continuous ultraviolet (UV) irradiation in order to simulate accelerated aging under environmental conditions. The exposure was carried out over a period of 21 consecutive days in a specialized closed chamber Weiss UV3 (Germany), designed to isolate samples from external lighting and provide stable irradiation within a controlled spectral range. The chamber emitted UV light in the wavelength interval of 290–450 nm, corresponding to the most photochemically active region of solar radiation. For the experiments, test plates of different thicknesses (from 1 to 5 mm) were prepared, with several replicates for each thickness in order to ensure reproducibility of results and to allow comparison of the influence of sample geometry on aging behavior [8,9].

The physical condition of the irradiated plates was systematically evaluated using both macroscopic and microscopic techniques. Visual examination focused on detecting changes in color, transparency, and surface uniformity, as well as the possible appearance of turbidity, which could indicate internal microstructural alterations. In addition, the formation of microcracks, bubbles, or other defects on the surface was monitored using a binocular optical microscope, which allowed for detailed analysis of fine morphological features that cannot be detected by the naked eye. Such combined visual and microscopic approaches provided a comprehensive assessment of the degree of photoaging [1,4].

To determine the effect of UV irradiation on the thermal stability of the studied systems, thermogravimetric analysis (TGA) was conducted both before and after irradiation. The measurements were performed within a broad temperature range of 30–600 °C under an inert nitrogen atmosphere, with a controlled heating rate of 10 °C/min. Approximately 1 g of finely ground sample was placed into an aluminum crucible for each measurement, ensuring uniform heat transfer. TGA [1,2,10] allowed the determination of the onset temperature of thermal decomposition, the rate of mass loss, and the overall stability of the materials. Comparison of thermal profiles before and after irradiation provided quantitative evidence of the changes induced by prolonged UV exposure and made it possible to evaluate the suitability of each binary copolymer system as a base for sealing materials intended for long-term operation under natural environmental conditions.

The experimental results revealed significant differences in the behavior of the three systems under UV exposure. The copolymers of p-EGF with acrylamide underwent noticeable changes: the samples hardened strongly, completely lost flexibility, and developed a rough surface, although no discoloration was observed. Such structural changes indicate the formation of additional intermolecular interactions, possibly hydrogen bonding, leading to increased rigidity. However, these additional crosslinks appear fragile under heat, which resulted in a pronounced reduction of thermal stability. In the case of the p-EGF–MAA system, prolonged UV exposure caused a slight yellow coloration, more evident in thinner plates, but no cracks or surface turbidity were detected. Finally, the copolymers of p-EGF with acrylic acid exhibited the highest stability, showing neither surface damage nor changes in color or flexibility after irradiation.

TGA confirmed these visual observations [1,10]. The temperature of the onset of thermal decomposition decreased drastically for the p-EGF–AAm system, from 134 °C before irradiation to 85 °C after exposure. This indicates that, despite the apparent hardening, the system becomes thermally unstable under the influence of UV light. For the p-EGF–AA and p-EGF–MAA systems, the decrease in thermal stability was much less pronounced. The onset of decomposition decreased from 146 °C to 132 °C in the case of p-EGF–AA, and from 172 °C to 151 °C for p-EGF–MAA. These values suggest that copolymers with carboxylic acids retain sufficient thermal stability even after prolonged UV exposure.

In summary, the study demonstrated that UV irradiation has a strongly negative effect on the thermal stability and physical properties of the copolymer system based on p-EGF with acrylamide, limiting its potential application as a base for sealing materials. By contrast, the systems with acrylic and methacrylic acids showed much higher resistance to irradiation. While p-EGF–MAA exhibited slight color changes, its thermal stability remained acceptable, and p-EGF–AA proved to be the most promising system, showing minimal structural or thermal degradation after irradiation.

The results of this investigation allow us to conclude that among the studied systems, the binary copolymers of p-EGF with acrylic acid are the most suitable candidates for the development of long-lasting sealing materials. These copolymers demonstrate a favorable combination of structural stability, resistance to UV-induced degradation, and retention of satisfactory thermal properties even after prolonged exposure. Unlike the systems with methacrylic acid or acrylamide, which showed either noticeable discoloration or a significant reduction in thermal stability, the p-EGF–AA copolymers maintained their physical integrity and exhibited only minimal changes in thermal decomposition behavior. This balance of characteristics suggests that p-EGF–AA based materials are more reliable under real service conditions, where sealing compounds are often exposed simultaneously to light, temperature fluctuations, and mechanical stress.

The significance of these findings extends beyond the laboratory, as they provide a scientific basis for the practical application of unsaturated polyester–vinyl systems in construction and related industries. Sealing materials that are resistant to UV radiation and capable of withstanding thermal stresses are essential for ensuring the durability of joints, cracks, and other vulnerable areas in buildings and engineering structures. The superior performance of the p-EGF–AA system

highlights its potential not only for traditional building applications but also for industrial sectors where polymer-based sealants are required to function under variable and sometimes aggressive environmental influences. By offering both reliability and longevity, this system can contribute to improving the operational safety, energy efficiency, and overall service life of construction materials and structures.

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## ПЭГИЛИРОВАННЫЕ НАНОЧАСТИЦЫ АЛЬБУМИНА ДЛЯ ИММОБИЛИЗАЦИИ ПРОТИВОТУБЕРКУЛЁЗНОГО ПРЕПАРАТА ИЗОНИАЗИДА

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В последнее время актуальным направлением является процесс модификации молекул различными полимерными соединениями. В мировой практике имеется опыт получения конъюгатов лекарственных средств связыванием - привязкой инертных макромолекул полиэтиленгликоля (ПЭГ). Лекарственно-содержащие конъюгаты ПЭГ не только обеспечивают хорошую переносимость, но и обладают улучшенным фармакокинетическим профилем, способствуют глубокому проникновению молекул и обеспечивают дополнительную защиту от действия протеолитических ферментов.

Полиэтиленгликоль (ПЭГ) является одним, из лекарственных синтетических полимерных инъекций, которые могут быть использованы для организма, которые одобрены управлением по контролю за качеством пищевых продуктов и лекарственных средств. Существуют многочисленные преимущества ПЭгилированных наносистем [1, 2].