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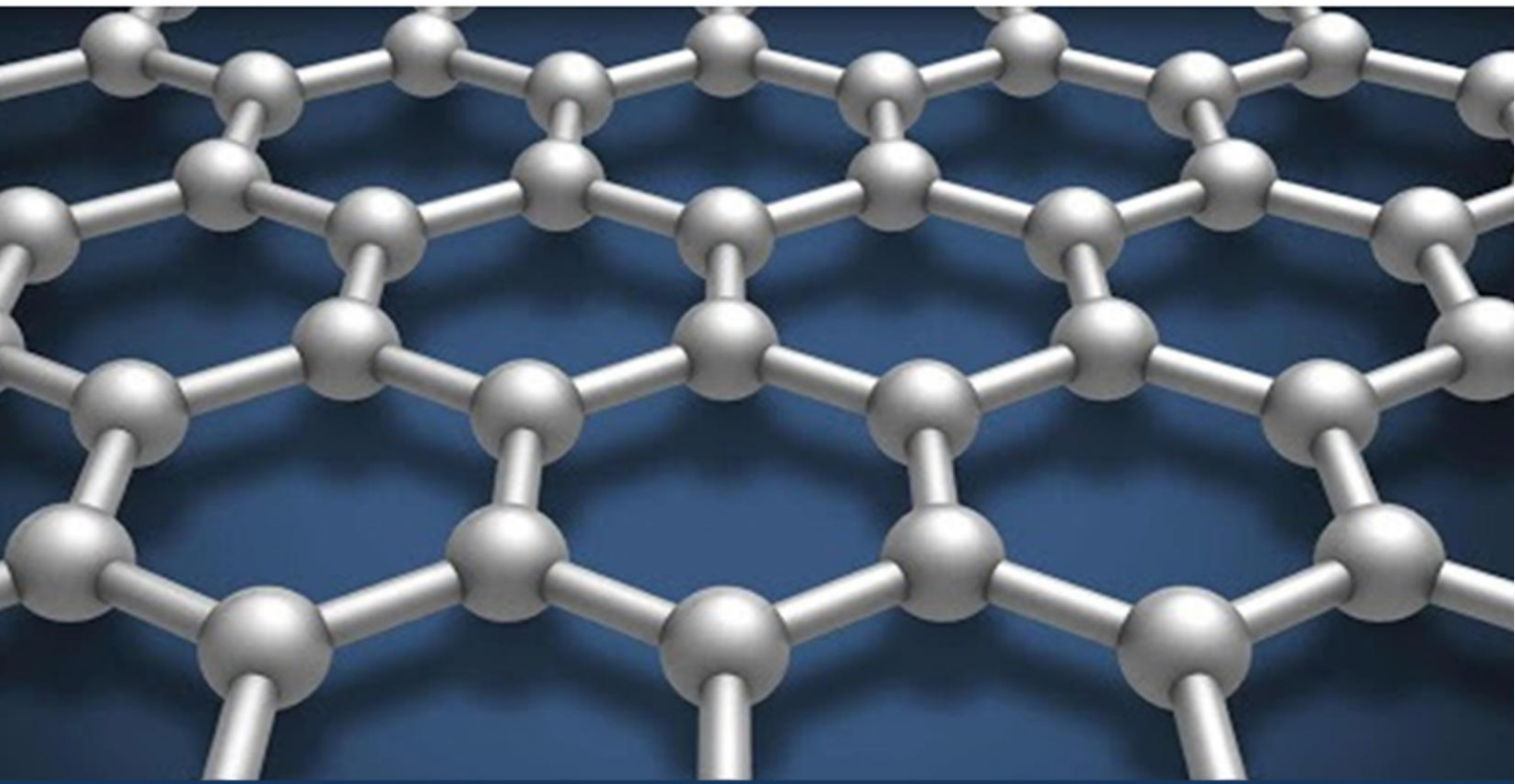

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Композиционные материалы

3.А.А.Исмаилов, Ш.П.Нуруллаев, А.М.Маматов. Адсорбционный метод очистки ионов тяжелых металлов сточных вод. Сборник статей Международной конференции «Материалы международная научно-практической конференции «Теоретическая и экспериментальная химия и современные проблемы химической технологии», Карши, 2023, стр.171.

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STUDY AND ANALYSIS OF POLYMERIC BINDERS USED IN WOOD-BASED PANEL PRODUCTION AND THEIR LIMITATIONS

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Abstract. This paper analyzes polymeric binders commonly used in the production of wood-based panels (particleboard, fiberboard, plywood, and wood–plastic composites) and identifies their limitations. Phenol–formaldehyde (PF) resins demonstrate high water resistance but are brittle and toxic due to free phenol and formaldehyde. Urea–formaldehyde (UF) resins have advantages in terms of cost and curing rate but suffer from poor moisture resistance and formaldehyde emissions. The study proposes modification of UF resin with reactive compounds such as epichlorohydrin and polyvinyl chloride (PVC) to improve curing kinetics and mechanical properties. FTIR spectroscopy confirms the formation of cross-linked structures. The modified binder shows enhanced bonding strength and water resistance, making it suitable for wood–plastic composite panels used in construction and furniture industries.

Keywords: urea–formaldehyde resin, phenol–formaldehyde resin, modification, epichlorohydrin, PVC, wood–plastic composites, FTIR.

Introduction. Wood-based panels such as particleboard (PB), fiberboard (FB), plywood, and wood–plastic composites (WPC) are widely used in construction, furniture, and automotive industries due to their affordability and versatility. The key component determining their performance is the polymeric binder. In the global market, there is a growing demand for composite materials with improved physical and mechanical properties, which can be achieved through effective polymeric binders and optimization of processing conditions.

In Uzbekistan, over 300,000 m³ of wood-based materials are consumed annually, with about 250,000 m³ imported. This indicates the necessity of developing local production technologies using agricultural waste (such as cotton stalks) and improved binders to reduce imports and increase competitiveness.

Literature Review and Problem Statement. PF and UF resins are the most common binders used in wood panel production. PF resins are widely used for their high water resistance and mechanical strength. However, cured PF resins are brittle and require modification to enhance toughness. They also contain free phenol and formaldehyde, which are toxic and harmful to health. The production of PF resins is limited in Uzbekistan due to the lack of phenol raw materials and high cost, making them expensive and scarce.

UF resins are commonly used due to their low cost and fast curing time. However, they exhibit poor water resistance and emit free formaldehyde, which limits their application in humid environments and poses environmental concerns. Therefore, modification of UF resins is essential to improve their properties and expand their use in wood-based panel production.

Materials and Methods. Materials

1. Urea–formaldehyde resin (UF) – commercial grade, solid content 60–62%
2. Epichlorohydrin – reactive modifier
3. Polyvinyl chloride (PVC) – reactive modifier
4. Ammonium chloride – curing agent
5. Wood particles – cotton stalks (ground)

Modification Procedure

The UF resin was modified by adding epichlorohydrin or PVC under controlled conditions. The mixture was stirred at 60–70°C for 30–45 minutes to ensure uniform distribution and reaction. After modification, the resin was cooled to room temperature and characterized.

Characterization Methods

1. Viscosity: measured using viscometer (VZ-4)
2. Curing time: determined by hot press at 120°C
3. Bonding strength: measured using standard tensile test (dry and wet conditions)
4. Water resistance: evaluated by boiling test
5. FTIR spectroscopy: used to confirm chemical structure changes

Results and Discussion. Physicochemical Properties of PF Resin (SFZh-3014). The PF resin SFZh-3014 is widely used for wood-based panel production due to its high water resistance. Table 1 summarizes its key properties according to GOST 20907-75

Table 1.

Physicochemical properties of PF resin SFZh-3014

Property	Value
Solid content (%)	46–52
Viscosity (VZ-4, s)	17–90
Alkalinity (%)	6.5–7.5
Free phenol (%)	≤ 0.10
Free formaldehyde (%)	≤ 0.15
Plywood shear strength after boiling for 1 h (MPa)	≥ 1.5

Despite high water resistance, PF resins are toxic due to free phenol and formaldehyde. They are also brittle and require modification for better toughness.

Comparison of UF Resin and Modified UF Resins. The properties of unmodified UF resin and modified UF resins (with epichlorohydrin and PVC) are presented in Table 2. The modification improves curing rate, bonding strength, and water resistance due to enhanced cross-linking and formation of more stable polymer networks.

Table 2.

Comparison of unmodified and modified UF resin properties

Property	Unit	UF (unmodified)	UF + epichlorohydrin	UF + PVC
Solid content	%	60–62	62–64	61–63
Viscosity	mPa·s	240–300	260–320	250–310
Curing time (120 °C)	s	55–60	45–50	50–55
Bonding strength (dry)	MPa	1.5–1.8	2.0–2.3	1.9–2.2
Bonding strength (wet)	MPa	0.7–0.9	1.2–1.4	1.1–1.3
Water resistance	h	2–3	5–6	4–5

The results show that modified UF resins demonstrate improved water resistance and mechanical properties, making them more suitable for manufacturing WPC panels.

FTIR Analysis. FTIR spectroscopy revealed the formation of new absorption bands corresponding to ether and epoxy groups, confirming the successful modification of UF resin. The appearance of these bands indicates increased cross-linking and improved structural stability, which contributes to better moisture resistance.

Conclusion. The study confirms that conventional UF and PF resins have limitations such as low water resistance, long curing time, and toxicity. Modification of UF resin with epichlorohydrin and PVC significantly improves bonding strength, curing kinetics, and water resistance. The modified UF binder can be used in the production of wood–plastic composite panels, contributing to local manufacturing and reducing dependence on imported materials.

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