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K.E. Varlan^a, *D.O. Chervakov*^b, *O.S. Sverdlikovska*^b, *E.C. Zahinayko*^c, *I.M. Severenchuk*^a**MODIFIED PHENOLIC RESINS AND THEIR COMPATIBILITY WITH THE COMPONENTS OF EPOXY-PHENOLIC PROTECTIVE COATINGS**^a Oles Honchar Dnipro National University, Dnipro, Ukraine^b Ukrainian State University of Chemical Technology, Dnipro, Ukraine^c Dnipropetrovsk Forensic Research Center of the Ministry of Internal Affairs of Ukraine, Dnipro, Ukraine

Condensation products of resorcinol mono-esterified by maleic anhydride, diphenylpropane with formaldehyde, products of maleinization and glycidation by butylphenol formaldehyde resins were synthesized. The obtained products can be used in film-forming systems. The methods of the synthesis were developed; the characteristics of the synthesized phenolic resins and the results of the IR-spectral analysis of intermediates and end products were given. Formulation of the model film-forming systems based on the synthesized resins was performed by predicting their thermodynamic compatibility with other components (oils and solvents) using Hildebrand parameters, the solubility being calculated by the Askadsky method. Experimental verification showed that the obtained results complied with the predictions on the compatibility of the synthesized resins with tung and epoxidized soy oils and solvents. The synthesized compounds can be considered promising components for protective coatings in combination with drying and epoxidized oils.

Keywords: maleic anhydride, resorcinol, diphenylpropane, modified phenolic resin, solubility parameter, protective coating.

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Introduction

Phenolic resins have been used in industrial-scale production for more than 100 years, though, they retain their relevance [1]; moreover, their demand shows a growing trend. Materials and goods based on phenolic resins are widely used in many fields due to the variety of their operational characteristics. For instance, phenolic resins are used as binders and film-forming components in the compositions for protective coatings [2]. It is known that paint compositions (paints and varnishes) for multi-functional protective coatings have been developed based on modified phenolic resins [3,4]. For example, phenolic resins based on alkylphenol are used in tin coatings [5]. Phenolic resins modified by epoxy resins are offered for enamels with improved physical-mechanical and thermal-physical properties [6]. Film-forming epoxy-phenolic systems containing phenolic resins, which are based on resorcinol, provide coatings with good adhesion to the metal and glass surfaces [7]. Coatings based on butanolized condensation products of diphenylpropane (BPA)

and formaldehyde [8–10] are characterized by unique physical-mechanical and protective properties.

According to analysis of available literature and patent data, the modified phenolic resins are important in the development of new epoxy-phenolic coatings. Modified phenolic resins based on *n*-tert-butylphenol (BP), resorcinol (R) and diphenylpropane have been synthesized. Their application as the components of epoxy-phenolic film-forming systems has been investigated to expand the range of phenolic derivatives applicable for epoxy-phenolic compositions, which are used in protective coatings with improved properties. There is also a feasibility to gain paint compositions, which combine performances of epoxy-phenolic and polyesters film-forming systems. There are two following ways to reach this goal: mono esterification of bis phenols by resorcinol and diphenylpropane by maleic anhydride (MA) with the next condensation of monomaleinates with formaldehyde and modification of *p*-tert-butylphenolformaldehyde resin (BR) through the esterification of maleic anhydride or

glycidation by epichlorohydrin (ECH).

Experimental

Synthesis of resorcinol and diphenylpropane adduct with maleic anhydride

Resorcinol (11.0 g, 0.1 mol), or diphenylpropane (11.4 g, 0.05 mol) and ethyl acetate were put into three-neck flask (0.1 L) equipped with a stirring rod, a thermometer and a backflow condenser. The mixture was stirred at 50°C until the solution creation. Then, 9.81 g (0.1 mol) of maleic anhydride was added. After the solution creation, the temperature was increased up to 70°C. The reaction mass was stirred for 3 hours. After a backflow condenser changed to direct, solvent was distilled at the atmosphere pressure, followed by water-jet pump vacuum up to 95°C. Remained yellow crystallized substances was solved in water and organic solvents (alcohol, acetone and toluene). Both melting temperature (T_m) and mole-equivalent masses (ME) were defined by potentiometry of carboxyl group (Table 1). A further transformations of adducts were carried out in the same reactor without preliminary withdrawals.

Table 1

The characteristics of adducts of bisphenols with maleic anhydride

Short name	Bisphenol	Ethyl acetate, mL	M_E , g/(mol-eq)	T_m , °C
PM	Resorcinol	25	213.7	130–131
DM	BPA	35	335.3	162–163

Synthesis of phenolic resin based on resorcinol adduct and maleic anhydride (PPR)

Water, 39% aqueous solution of formaldehyde

and, if needed, oxalic acid (OA) were added to PM adduct. Then, the mixture was stirred at ambient temperature until the solution creation. The reaction mass was stirred at 75°C for 3 hours and at 85°C for 1 hour. After obtaining a viscous and homogeneous mass, butyl alcohol was added whereas water was extracted by azeotropic distillation with Dean-Stark trap. Then, butyl alcohol was distilled over the vacuum of a waterjet pump up to 110°C. The final product was resinoid transparent red substance, which is readily soluble in acetone, toluene and alcohol, however, insoluble in water. The ingredients, which were not mentioned above, are shown in Table 2.

Synthesis of phenolic resin based on adduct of diphenylpropane with maleic anhydride (DPR)

The synthesis is similar to the above-stated until the end of the condensation of the adduct with formaldehyde. At the end of the reaction, a mass was separated into tar-water and organic product, which hardened at room temperature. Water part was extracted; butyl alcohol was added to the reactor where the mass was stirred at 45–50°C for 2 hours. Butyl alcohol was distilled under vacuum at 95°C. The final product was resinoid transparent light brown substance, which is water-insoluble, readily soluble in acetone and poorly soluble in toluene and alcohol. The ingredients, which were not mentioned above, are presented in Table 2.

Synthesis of comparative samples of phenolic resins based on resorcinol adducts and diphenylpropane with maleic anhydride (PPR' and DPR', respectively)

These products were synthesized by similar methods. The only difference was the use of toluene instead of butyl alcohol (in both cases).

Table 2

Synthesis conditions and modified phenolic resins characteristics

Short name	Adduct, mol	Formaldehyde, mol	OA, mol	H ₂ O, mL	Butyl alcohol, mL	T_{grs} , °C
PPR-1	0.10	0.085	0.01	22.0	30	54
PPR-2	0.10	0.085	–	22.0	30	71
PPR-3	0.10	0.090	0.01	21.5	30	93
PPR-4	0.10	0.100	–	20.5	30	99
PPR-5	0.10	0.125	–	18.0	30	103
PPR-6	0.10	0.125	0.01	18.0	30	–*
DPR-1	0.05	0.05	–	35.0	40	67
DPR-2	0.05	0.055	0.01	34.5	40	60
DPR-3	0.05	0.060	–	34.0	45	57
DPR-4	0.05	0.063	–	34.0	45	85
DPR-5	0.05	0.100	–	30.0	45	66
DPR-6	0.05	0.100	0.01	30.0	45	–*
DPR-7	0.05	0.151	–	25.0	50	63
DPR-8	0.05	0.200	–	20.0	50	–*

Note: * – Obtained gellike substance is not applicable.

Synthesis of *n*-tert-buthylphenolformaldehyde (BR)

BR was synthesized by condensation of *n*-tert-buthylphenol with para-form at the molecular ratio of 1:1.3 in sour ambient [3]. The final product was brittle transparent yellow mass ($T_{cr}=91^{\circ}\text{C}$).

Synthesis of maleinized *n*-tert-buthylphenol-formaldehyde (MBR)

A mixture of 16.2 g (0.1 mol-equivalent) of *n*-tert-buthylphenolformaldehyde, 9.8 g (0.1 mol) of maleic anhydride and 50 mL of ethyl-acetate was transformed into the three-necked reactor (0.2 L) which was equipped with a stirring rod, a backflow condenser and batch plant. The mass was heated until boiling, and then mixed for 1 hour. Backflow condenser was changed to direct flow one, when the solvent was distilled firstly at the atmospheric pressure then under water-jet vacuum up to 130°C . The final product was brittle yellow transparent in thin layer substance, which is soluble in ethyl-acetate but carbohydrate-insoluble, $T_{cr}=112^{\circ}\text{C}$.

Synthesis of glycidated buthylphenolformaldehyde resin (GBR)

A mixture of 6.7 g (0.041 mol-equivalent) of buthylphenolformaldehyde resin, 45 mL distilled water and 1.76 g (0.044 mol) of NaOH was transformed into three-necked reactor (0.1 L) which was equipped with a stirring rod and backflow condenser. The mass was mixed at 55°C for 30 minutes up to solution creation where amorphous deposit was rejected at cooling, which then transformed into plastic mass. 3.7 g (0.040 mol) of epichlorohydrin was added to the reaction mass and mixed at 30°C for 90 minutes. The next step was to add 20 mL of benzol and then to mix for 30 min. After that, the mass was poured into a separating funnel. As soon as the phases were separated, the organic layer was extracted, rinsed by distilled water until getting neutral reaction according to phenolphthalein, and exposed to azeotropic dehydration by Dean-Stark trap. The solvent with the rest of epichlorohydrin was distilled, firstly at the atmospheric pressure then under water-jet vacuum up to 100°C . The final product was greenish-yellow transparent sticky mass. The content of epoxy groups was 5.9%.

IR spectroscopy

IR spectra were collected by FT-IR analysis with the module Nicolet iZ10, adaptor Smart iTX ATR with the crystal Diamond and detector DTGS. Absorption bands ratio in spectra was conducted taking into account recommendations given elsewhere [11].

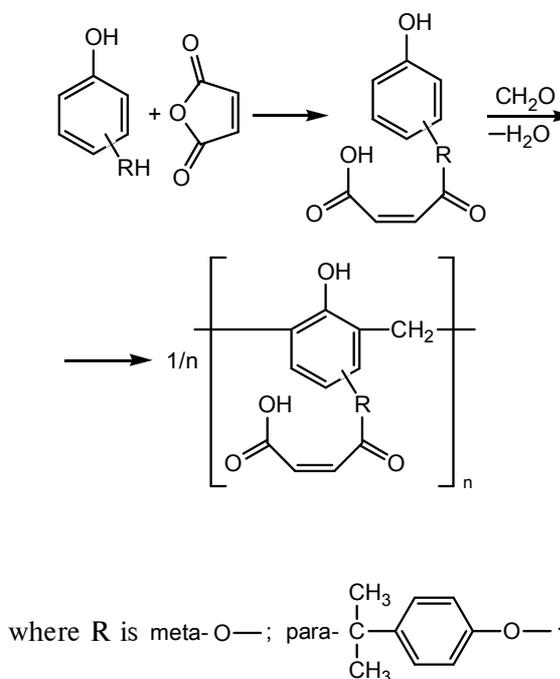
Calculations of Hildebrand solubility parameters

and prediction of substances compatibility were conducted by Askadsky method [12].

Protective coatings tests were conducted according to the Ukraine technical conditions No. 00393707-002-95.

Results and discussion

The synthesis of modified phenolic resins based on maleinized *n*-tert-buthylphenol was conducted by the following scheme:



Scheme 1. Synthesis of modified PR based on maleinized BR

Data given in Table 2 show the synthesis conditions and the main characteristics of modified phenolic resins at different ratios of adduct.

An increase in the amount of formaldehyde results in an increase in T_{cr} . Adduct acidity is sufficient for the catalysis of condensation by formaldehyde. It is important to note that the acid catalyst facilitates preparation of end product in case of a low amount of formaldehyde in the reaction mixture, whereas the catalyst introduction is unfavorable in case of an increased amount of formaldehyde, because a cross-linked product is obtained.

The above-mentioned processes and structures of adducts and modified phenolic resins have been confirmed by IR-spectral data. Specific absorption bands are shown in Table 3.

The spectra of PM and DM do not reveal absorption bands at 1854 , 1782 , 1242 and 1059 cm^{-1} , which are typical of MA; this indicated the reaction behavior with the opening of anhydride ring. The

Table 3

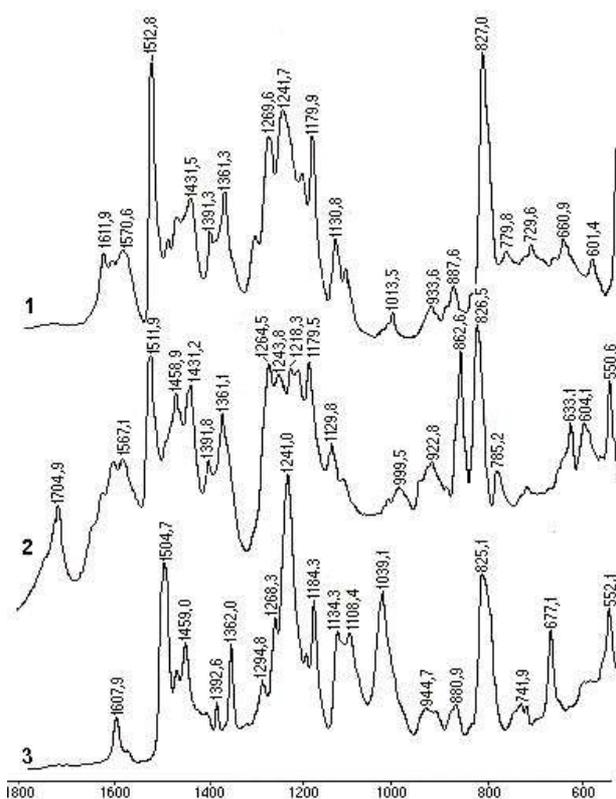
Specific absorption bands in IR-spectra of modified phenolic resins, initial products and their adducts

Compound	Values of absorption bands, cm ⁻¹
MA	1854; 1782; 1636; 1585; 1242; 1059; 896; 839; 696
Resorcinol	3207; 3064; 3053; 3036; 1620; 1608; 1458; 1381; 1312; 1297; 1285; 1225; 1168; 1152; 1085; 998; 963; 945; 930; 844; 773; 684
PM	3172; 3057; 1704; 1604; 1566; 1488; 1458; 1430; 1378; 1262; 1219; 1167; 1147; 961; 917; 861; 842; 772; 739; 679; 633; 608; 593; 543
PPR	3247; 3058; 2959; 2936; 2872; 1702; 1616; 1508; 1443; 1411; 1378; 1212; 1162; 1083; 1020; 975; 842; 627; 591
DPA	3346; 3030; 2965; 2870; 1883; 1611; 1594; 1509; 1446; 1383; 1362; 1295; 1237; 1177; 1149; 1064; 1013; 827; 758; 552
DM	3181; 3057; 1703; 1605; 1488; 1459; 1429; 1376; 1295; 1219; 1166; 1145; 960; 862; 842; 771; 739; 679; 633; 611; 543
DPR	3256; 3049; 2964; 2936; 2868; 1704; 1609; 1501; 1423; 1361; 1224; 1176; 1147; 1115; 1040; 1013; 882; 819; 553

presence of absorption bands at 2936 and 2872–2868 cm⁻¹ in the spectra of PPR and DPR corresponds to valent and bending vibrations of C–H in methylene group. Intensive absorption bands at 2964–2959 cm⁻¹ in the spectra of PPR and DPR can be associated with asymmetrical valent bending vibrations in –CH₃ groups, which were introduced as a result of butanolisis when synthesized. The spectra of PM, DM, PPR and DPR demonstrate the bands at 3049–2058 cm⁻¹, which are typical of asymmetrical valent vibrations of C–H in alkenes, and the intensive bands at 1704–1702 cm⁻¹, which show valent vibrations of C=O in the group >C=C–COOH. In addition, the bands at 1604–1616 cm⁻¹ are observed, which correspond to valent vibrations >C=C< in the presence of conjugation with C=O group.

The band at 1704.9 cm⁻¹ is present in the spectrum of MBR (Figure), which corresponds to valent vibration of C=O group in α,β-unsaturated acids. The band at 1218.3 cm⁻¹ may be due to vibrations of C–O–C in esters. The band at 1134.3 cm⁻¹, 1108.4 cm⁻¹ and 1039.1 cm⁻¹ in the spectrum of GBR corresponds to valent vibrations of C–O–C in cyclic and linear ethers.

Systems based on modified phenolic resins with vegetable oil and their derived products are efficient protective coatings. For instance, these are the compositions synthesized by combining of phenolic resins, epoxide resins, vegetable oil, mainly tung-oil (TO) [4]. To understand the application of the synthesized phenolic resins as the components of film-forming systems, they were tested in model compositions that include vegetable oil or they derived products. Composition content was identified by the results of prospective compatibility of phenolic resins with other ingredients of protective



IR-spectra of BP (1), MBR (2) and GBR (3)

compositions by comparison of Hildebrand solubility parameter that was calculated by the following equation developed by Askadsky [12]:

$$\delta = \left(\frac{\sum_i \Delta E_i^*}{N_A \sum_i \Delta V_i} \right)^{0.5}, \quad (1)$$

where δ is the Hildebrand solubility parameter ($\text{J}^{0.5} \text{m}^{-1.5}$); ΔE_i^* is the contribution of the i -th atom or the type of intermolecular interaction to the value of the cohesion energy of matter (J mol^{-1} ; N_A is the Avogadro constant (mol^{-1}); ΔV_i is the increment of the Van-Der-Waals volume of the i -th atom of matter (\AA^3).

The results of calculation performed by using formula (1) are given in Table 4.

Table 4
Characteristics of synthesized PR and vegetable oil

Compound	$\Sigma \Delta E_i^*$, J mol^{-1}	$\Sigma \Delta V_i$, \AA^3	δ , $\text{J}^{0.5} \text{m}^{-1.5}$
BR	9598.5	175.6	19.5
MBR	17553.5	252.7	22.0
GBR	14014.0	226.4	20.7
PPR'	14717.3	182.9	23.7
DPR'	22486.6	309.4	22.5
PPR	13372.7	237.4	19.8
DPR	18939.2	380.1	18.6
ER ¹	25101.6	380.1	21.4
EO ²	54540.2	987.5	19.6
TO	41161.6	991.0	17.0

Notes: ¹ – Epikote-828 is an epoxydiane resin based on BPA produced by HEXION, analogue of ED-22; ² – ArStab-1701 is an epoxydiane soybean oil produced by «Arsenal-group» Ltd., UTD 24.1-32926424-001:2012.

According to the available data [13,14], thermodynamic compatibility of substance and solvent is feasible if the following condition is fulfilled:

$$|\delta_1 - \delta_2| \leq (3.07 \div 4.09) \cdot \text{MJ}^{0.5} \cdot \text{m}^{-1.5}, \quad (2)$$

where δ_1 and δ_2 are the solubility parameters concerning the solvent and the substance, respectively

($\text{MJ}^{0.5} \text{m}^{-1.5}$).

If TO or EO is considered as a solvent, then according to the calculation results, the rest of above mentioned substances are supposed to change the solubility in the following sequence (the value of $|\delta_1 - \delta_2|$ is given here in brackets):

– for TO:

DPR(1.6) > BR(2.5) > EO(2.6) > PPR(2.8) > GBR(3.8) > ER(4.4) >> MBR(5.0) > DPR'(5.5) > PPR'(6.7);

– for EO:

BR(0.1) > PPR(0.2) > GBR(1.1) > EC(1.8) > > MBR(2.4) > TO(2.6) > DPR'(2.9) >> PPR'(4.1).

According to the above-mentioned data, TO is likely to be compatible with synthesized phenolic resins, such as DPR, BR, PPR and GBR as well as epoxy-containing substances; whereas EO is likely to be compatible with all investigated substances phenolic resins except for PPR'.

Similar calculations were performed for the system organic solvent–phenolic resins, oil and epoxy-containing substances to predict the choice of the solvents suitable to make stable solutions with the synthesized substances. The data about the chosen organic solvents and the results of calculation are listed in Table 5.

It is seen from Table 5 that carbohydrate aromatic and aliphatic solvents can make thermodynamically compatible systems with oils, ER, BR, and butanolized products of condensation of adducts of bisphenol-maleic anhydride with formaldehyde. Moreover, there are some suitable solvents for indicated substances such as tetrahydrofuran, ethyl acetate, acetone and dioxane.

Table 5
Data about predicted compatibility of organic solvents and PR, oil and epoxy-containing substances

Solvent*	δ_1	$ \delta_1 - \delta_2 $, for substances									
		BR	MBR	GBR	PPR'	DPR'	PPR	DPR	Epikote-828	ArStab-1701	TO
WS	17.7	1.8	4.3	3.0	6.0	4.8	2.1	0.9	3.7	1.9	0.7
Toluene	18.2	1.3	3.8	2.5	5.5	4.3	1.6	0.4	3.2	1.4	1.2
TGF	18.5	1	3.5	2.2	5.2	4.0	1.3	0.1	2.9	1.1	1.5
EA	18.6	0.9	3.4	2.1	5.1	3.9	1.2	0.0	2.8	1	1.6
Acetone	20.0	0.5	2.0	0.7	3.7	2.5	0.2	1.4	1.4	0.4	3.0
Dioxane	20.2	0.7	1.8	0.5	3.5	2.3	0.4	1.6	1.2	0.6	3.2
NB	23.3	3.8	1.3	2.6	0.4	0.8	3.5	4.7	1.9	3.7	6.3
IPA	24.0	4.5	2.0	3.3	0.3	1.5	4.2	5.4	2.6	4.4	7.0
Ethanol	26.0	6.5	4.0	5.3	2.3	3.5	6.2	7.4	4.6	6.4	9.0
Methanol	29.6	10.1	7.6	8.9	5.9	7.1	9.8	11.0	8.2	10.0	12.6

Note: * WS – white spirit; TGF – tetrahydrofuran; EA – ethyl acetate; NB – n-butyl alcohol; and IPA – isopropyl alcohol.

As for PPR' and DPR', which were not processed by butyl alcohol, they are compatible with solvents with δ_1 of 20 to 26 MJ^{0.5} m^{-1.5}. The highest efficiency with respect to the solubility of investigated mixtures of phenolic resins, oils and epoxy-containing substances are expected to be the solvents with δ_1 of 19.7 to 21.0 MJ^{0.5} m^{-1.5}. Liquids with these parameters can be prepared by the addition of individual solvents in a certain ratio. In this case, the value δ_{ij} is calculated by the following formula:

$$\delta_{ij} = \frac{x_i V_i \delta_i + x_j V_j \delta_j}{x_i V_i + x_j V_j}, \quad (3)$$

where δ_{ij} is the solubility parameter of the solvents mixture; $x_{i(j)}$, $V_{i(j)}$, and $\delta_{i(j)}$ are the mole fractions, mole volumes (cm³ mol⁻¹) and solubility parameters (MJ^{0.5} m^{-1.5}); the subscripts i and j are related to the individual different solvents.

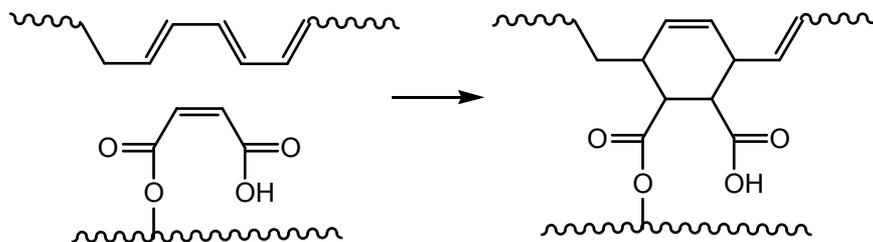
It is interesting to note that indicated range of x_{ij} is obtained by the mixture of ethyl acetate and other mentioned solvents providing that the mole fractions in a mixture is as follows: acetone: from 1.0 to 0.8; dioxane: from 1.0 to 0.7; n-butyl alcohol

and isopropyl alcohols: from 0.5 to 0.3; and ethanol and methanol: from 0.4 to 0.3.

The experimental tests showed that the conclusions about the compatibility of phenolic resins with oils and organic solvents with synthesized phenolic resins are valid. The composition and characteristics of homophasic transparent mixtures are shown in Table 6.

Stable compositions based on thermodynamically incompatible TO and MBR are prepared by preliminary thermostating of their mixtures of TO-phenolic resin at increased temperature. Plausible reason for the formation of a homophasic system is a compatibilization effect resulted from the Diels-Alder reaction between fragments of conjugated non-saturated groups in remains of elaeostearic acid in TO and non-saturated group of the maleic group according to the following scheme 2.

The composition based on basic recipe of means of sophistication R 101, where ingredients Epikote-828 and BR SMD 31144 were substituted by equivalent amount of synthesized GBR, was tested. According to results of the tests, the obtained coatings satisfy all technical rules and regulations.



Scheme 2. Diels-Alder reaction

Table 6

Composition and characteristics of model compositions

No.	Content of components, wt.%								Drying duration, h		Properties of coating			
	MBR	PPR	DPR	TO	EO	WS	EA	NB	20°C	110°C	adhesion, points	Elasticity, mm	Resistance to environments ³	
													seawater	mineral oil
1	50						50		4	8	4	4	n.p.	n.p.
2	25			25			50		3	3	2	4	p.	p.
3 ¹	20			20	10		50		3	3	1	2	p.	p.
4 ²	20			20	10		50		3	—	1	1	p.	p.
5		17			6		77		4	3	3	3	n.p.	p.
6		17			6	10	67		4	3	2	3	p.	p.
7			37		5		58		4	2	3	2	p.	p.
8			37		5			58	4	3	2	1	p.	p.
9			37		5		34	24	4	3	1	2	p.	p.
10			36		7		34	23	4	3	1	1	p.	n.p.

Notes: ¹ – explanation is given in the main text; ² – the composition contained 0.3% of desiccant and a mixture of Co, Mn and Zn naphthenates; ³ – «n.p.» means that the coating has not passed the test, «p.» means that the coating has passed the test.

Conclusions

Modified phenolic resins, prepared by monoesterification of bisphenols by maleic anhydride and further condensation with formaldehyde as well as esterification by maleic anhydride or glycidation of phenol-formaldehyde resins by epichlorohydrin, can be suggested as components of protective coatings in a combination of drying oils and epoxidated oils. Development of compositions for protective coatings is efficient to be done taking into account Hildebrand solubility parameters of filmmaking components and solvents.

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МОДИФІКОВАНІ ФЕНОЛЬНІ СМОЛИ ТА ЇХ СУМІСНІСТЬ З КОМПОНЕНТАМИ ЕПОКСИ-ФЕНОЛЬНИХ ЗАХИСНИХ ПОКРИТТІВ

К.Є. Варлан, Д.О. Черваков, О.С. Сverdlikovska, Є.С. Загинайко, І.М. Северенчук

Для одержання перспективних плівкоутворювальних систем синтезовані продукти конденсації моноестерифікованих малеїновим ангідридом резорцину, дифенілпропану з формальдегідом, продукти малеїнування та гліцидування бутилфенолформальдегідної смоли. Наведено методики синтезів, характеристики синтезованих фенольних смол і результати ІЧ-спектрального аналізу проміжних та кінцевих продуктів. Складання рецептур модельних плівкоутворювальних систем на основі синтезованих смол здійснювали шляхом прогнозування їх термодинамічної сумісності з іншими компонентами (оліями, розчинниками) за допомогою параметрів розчинності Гільдебранда, розрахованих за методом Аскадського. Експериментальна перевірка показала відповідність отриманих і прогнозованих результатів щодо сумісності синтезованих смол з тунговою та епоксидованою соєвою оліями і розчинниками. Синтезовані сполуки можуть розглядатися як компоненти захисних покриттів в комбінації з висихаючими та епоксидованими оліями.

Ключові слова: малеїновий ангідрид, резорцин, дифенілпропан, модифікована фенольна смола, параметр розчинності, захисне покриття.

MODIFIED PHENOLIC RESINS AND THEIR COMPATIBILITY WITH THE COMPONENTS OF EPOXY-PHENOLIC PROTECTIVE COATINGS

K.E. Varlan ^{a,*}, D.O. Chervakov ^b, O.S. Sverdlivskva ^b,
E.C. Zahinayko ^c, I.M. Severenchuk ^a

^a Oles Honchar Dnipro National University, Dnipro, Ukraine

^b Ukrainian State University of Chemical Technology, Dnipro, Ukraine

^c Dnipropetrovsk Forensic Research Center of the Ministry of Internal Affairs of Ukraine, Dnipro, Ukraine

* e-mail: konstvarlan@meta.ua

Condensation products of resorcinol mono-esterified by maleic anhydride, diphenylpropane with formaldehyde, products of maleinization and glycidation by butylphenol formaldehyde resins were synthesized. The obtained products can be used in film-forming systems. The methods of the synthesis were developed; the characteristics of the synthesized phenolic resins and the results of the IR-spectral analysis of intermediates and end products were given. Formulation of the model film-forming systems based on the synthesized resins was performed by predicting their thermodynamic compatibility with other components (oils and solvents) using Hildebrand parameters, the solubility being calculated by the Askadsky method. Experimental verification showed that the obtained results complied with the predictions on the compatibility of the synthesized resins with tung and epoxidized soy oils and solvents. The synthesized compounds can be considered promising components for protective coatings in combination with drying and epoxidized oils.

Keywords: maleic anhydride; resorcinol; diphenylpropane; modified phenolic resin; solubility parameter; protective coating.

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