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Influence of TAS Photoinitiator on UV-Curing and Performance of Coating Based on a Bicycloaliphatic Diepoxide and Epoxy Resin Modified by Black Seed Oil

Le Xuan Hien[1*], Do Minh Thanh[1], Nguyen Minh Duc[2]
[1]Institute for Tropical Technology, Vietnam Academy of Science and Technology, Hanoi, Vietnam
[2]Thuyloi University, Hanoi, Vietnam
[*]Corresponding author email: lxhienvktnd@gmail.com

Abstract

Influence of photoinitiator triarylsulfonium hexafluoroantimonate salts (TAS) on UV-curing and performance of coatings based on 3,4-epoxycyclohexylmethyl 3,4-epoxycyclohexane carboxylate - a bicycloaliphatic diepoxide (BCDE) and epoxy resin modified by black seed oil (EBSO) have been studied. The variation of TAS and functional groups of investigated coatings during UV-exposure was followed by infrared spectrometric analysis. The properties of UV-cured coatings such as gel fraction, relative hardness, flexibility and gloss were determined. It was shown that UV-curing of investigated coatings was markedly affected by their TAS initial concentration: When TAS initial concentration in the coatings enhanced from $6x10^{-3}$*mole/kg to* $37.5x10^{-3}$ *mole/kg, the photolysis of TAS, consumption of epoxy groups, formation of hydroxyl and ether groups increased from* $3.78x10^{-3}$ *mole/kg, 3.47 mole/kg, 40% , 177% to* $28.5x10^{-3}$ *mole/kg, 4.4 mole/kg, 327% and 1223%, respectively, after 1.2s of UV-exposure. At the same time the performance of the UV- cured coatings was insignificantly changed. Their gel fraction and relative hardness decreased from 84.2% and 0.86 to 69.98% and 0.78 while flexibility and gloss at* 60^o *remained unchanged to be 10 mm and 100%.*

Keywords: Bicyclo-aliphatic diepoxide, black seed oil, photoinitiated cationic polymerization, triarylsulfonium salts

1. Introduction

It is well known that since the discovery by Crivello at the end of the 70s years of last century cationic photopolymerization is continuously developed and attracts the attention of scientists as well as producers to both academic and practical sides due to its distinguished advantages such as high productivity, effectiveness and environment safety process, high performance of photocrosslinked products, the lack of oxygen inhibition, the possibility of continuation of the process in the dark when light source is switched off, the effective use of various epoxy compounds in formulations etc. [1-4].

As usual UV formulations, UV photoinitiated cationic formulations consist of photoinitiators, oligomers, monomers, additives, fillers and pigments. Since the chemical nature and content of each among the constituents in the formulations are able to affect in various extent to photocrosslinking and performance of UV-cured products, systematical research always has to be realized for their option [5-8].

It is reported that optimal contents of photoinitiators in UV-curable formulations are ranged from 1 to 10 weight % in dependence on the aim of the formulators [4]. Among cationic photoinitiators which are commercially available known so far triarylsulfonium salts are most important due to their high efficiency, thermal stability, no gas release in photolysis [9]. General chemical formula of the salts can be presented as following: $X^+[Ar_2SArSArSAr_2]^+X$, where Ar : Benzene ring, X: $PF6^-$, $AsF6^-$, $SbF6^-$. As shown in their formula, the salts consist of cationic and anionic moieties. The cationic part is the light absorbing component and answer for the photochemistry. Its structure determines the UV absorption feature, the photosensitivity, the quantum yield as well as thermal stability of the salts. Meanwhile, the structure of the anion part is responsible for the strength of the acid produced in the photolysis of the salts, its initiation efficiency and behavior of the propagating ion pair which surely influences on both of the kinetics of polymerization and the termination rate. Under UV exposure the molecules of the salts are subjected to photolysis involving photoexitation and the decay of the resulting excited singlet state. The highly reactive cations and radicals produced in the photolysis further react with hydrocarbon compounds in the system to generate protonic superacids. The protons of the superacids thus initiates the cationic photopolymerization [1-8]. The bigger is the anion, the lower is its nucleophilicity and therefore, the

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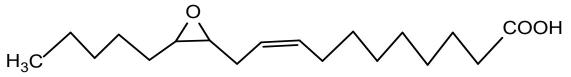
stronger the formed superacid. It was informed that the acidity of super protonic acids formed during photolysis of triarylsulfonium salts having anions PF_6^-, AsF_6^-, SbF_6^- can be arranged in the following order $HPF_6 < HAsF_6 < HSbF_6$. The higher the acid strength the faster the initition rate of the cationic UV- curing [1].

One of the disadvantages of the triarylsulfonium salt photoinitiators is their rather short maximum absorption wavelength of UV light (about 220-280 nm). Many efforts have been devoted to obtain salts with a longer maximum absorption wavelength. This was achieved by the preparation of triphenyl sulfonium salt having thiophenol group in its molecular structure leading to the appearance in the market of a new triarylsulfonium salt cationic photoinitiator containing thiophenol group with absorption region from 300 to 360 nm due to improvement of its degree of conjugation [9].

One of the notable merits of cationic photopolymerization is the use of epoxy monomers and oligomers, compounds with wide and important applications in various fields such as high performance coatings, composites, electric and electronic technics, aerospace technology etc., in its formulations. The advantages of materials based on epoxy compounds are low shrinkage during the curing process, high chemical, thermal, moisture resistance, high adhesion on the polar surfaces. Side by side with these the materials often have some shortcomings like brittleness, low toughness. The disadvantages can be overcome by introducing rubbers, vegetable oils or their derivatives in the materials formulations. By the way, one can increase the mobility of the system, favor the curing reaction and improve the performance of the materials. Consequently, the use of vegetable oils and their derivatives containing epoxy groups attracts uninterrupted attention of UV-curable coating formulators. However, there are still few reports about the topics [5-8].

It is well known that epoxy groups in vegetable oils or their derivatives can be naturally occurring or result of various chemical modification processes [5,8,10,11]. One of vegetable oils containing naturally occurring epoxy groups is black seed oil (BSO). The black tree (Cleidiocarpon cavaleriei) is a log of wood and growths a lot in North - West Vietnam. It was reported that BSO is a triglyceride oil having 73 - 85% of *cis*-12,13-epoxy-*cis*-9-octadecenoic acid (vernolic acid) in its fatty acid composition) [10].



Cis-12,13-epoxy-*cis*-9-octadecenoic acid (vernolic acid)

It can be noticed that BSO with above mentioned structure may be a perspective constituent for cationic UV- curable formulations. However, up to now it is hard to find information about the use of BSO or its derivatives in UV- curing formulations in published literature.

The research of photoinitiated cationic polymerization of the coatings based on epoxy resin modified by black seed oil (EBSO), 3,4-epoxycyclohexylmethyl 3,4-epoxycyclohexane carboxylate - a biscycloaliphatic diepoxide (BCDE), triarylsulfonium hexafluoroantimonate salts (TAS) cationic photoinitiator was realized at the Laboratory for Rubber and Natural Resins Materials (LRNRM), Institute for Tropical Technology (ITT), Hanoi in order to contribute in solving the problem. The role of EBSO and BCDE in investigated coating formulations have been discussed [12]. The influence of the content of the coating constituents on UV-curing and performance of UV cured coatings has been systematically investigated in the research. As a part of the research, the results of the study of the influence of the EBSO/BCDE weight ratio in the coating on UV-curing and performance of UV cured products have been reported [12]. The results of the remaining part, study of the influence of the TAS content in the coatings on UV- curing and performance of UV cured products are presented in this article.

It was demonstrated that the increase of the EBSO/BCDE weight ratio in the investigated coatings from 20/80 to 80/20 significantly slowed down their UV - curing, reduced their relative hardness after 1.2 s of UV exposure from 0.84 to 0.16 and enhanced flexibility of the cured coatings from 10 to 1 mm. At the same time the other properties of the cured coatings such as the gloss at 60ºC and the gel fraction remained the same or changed inconsiderably [12]. So, one have the opportunity to obtain the cured coatings with wide range of properties, from very hard to soft and flexible suited various application by proper choice the EBSO/BCDE weight ratio in coating formulation.

Since the coatings with high relative harness and gloss are very perspective for the use as finish layer in different high performance coatings, the weight ratio EBSO/BCDE equal 20/80 was selected for the preparation of the coating formulations in this work.

The objective of the present work was to study influence of the content of TAS on UV-curing and performance of the coatings having the weight ratio EBSO/BCDE equal 20/80.

2. Experiment

2.1. Materials

TAS were obtained from Aldrich, USA in the form of UVI 6974 - a mixture of 50% weight of TAS in propylene carbonate. EBSO with the oil content residue of 39% and epoxy group content of

2.51 mole/kg was prepared at the LRNRM, ITT, Hanoi. The preparation was performed via chemical modification of a dian epoxy resin by BSO at 230 ºC, moderate stirring rate. The modification process comprises mainly re-esterification of BSO by hydroxyl groups, etherification of hydroxyl groups of epoxy resin and mono-, di-glyceride produced in the re-esterification reaction…resulting in the formation of products having the moieties of both epoxy resin and BSO in their molecular. Therefore, EBSO contains glycidyl epoxy, hydroxyl, ether groups, aromatic rings of dian epoxy resin and epoxy, carbonyl groups of the oil residue as well as hydroxyl and ether groups produced in the modification process [5]. BCDE (Cyracure 6105) was supplied by Aldrich, USA. Chloroform of PA grade was purchased from China.

2.2. Preparation of UV-Curable Formulations

Formulations with the weight ratio EBSO/BCDE equal 20/80 and TAS contents from 1 to 7% of total EBSO, BCDE weight (Table 1) were made by thoroughly stirring the compounds.

Coatings of the formulations were applied on KBr crystal for IR-analysis, on glass plates or on steel, copper plates for determination of their properties. The coating application were realized by the use of suitable spiral applicators (Erichsen), to make wet films about 10 (for IR analysis) and 30 µm (for determination of properties).

Table.1. Investigated UV-curable formulations

No	UV-curable formulations (weight parts) EBSO/BCDE/TAS	TAS and total epoxy group content (mole/kg)	
		TAS	Epoxy
1	20/80/1	6.0×10^{-3}	6.67
2	20/80/2.5	15.0×10^{-3}	6.47
3	20/80/5	27.8×10^{-3}	6.18
4	20/80/7	37.5×10^{-3}	5.90

2.3. UV Exposure

Investigated coatings were exposed by UV irradiation in a Fusion UV (model F 300S), USA having medium - pressure mercury lamps with light intensity of 250 mW/cm^2.

2.4. Analysis

The record of IR spectra was performed by means of an FT-IR spectrophotometer (NEXUS, 670, Nicolet), USA. Quantitative determination of the change of TAS and functional groups during UV irradiation was realized by the internal standard method. The concentration C_t of TAS or epoxy, hydroxyl, ether groups in investigated coatings at the UV exposure time *t* was calculated as follows:

$$C_t = C_0 \text{ x } \left[\frac{D_{IG}}{D_{1510}}\right]_t \Big/ \left[\frac{D_{IG}}{D_{1510}}\right]_0$$

where:

- C_t: Concentration of TAS or investigated groups (epoxy, hydroxyl, ether) at the moment *t* of UV exposure.
- C_0: Initial concentration of TAS or investigated groups.
- D_{IG}: Optical density of the absorption band characteristic for TAS or investigated groups (epoxy, hydroxyl, ether).
- D_{1510}: Optical density of the absorption band characteristic for benzene ring (internal standard).
- $\left[\frac{D_{IG}}{D_{1510}}\right]_0$: The initial ratio $\left[\frac{D_{IG}}{D_{1510}}\right]$
- $\left[\frac{D_{IG}}{D_{1510}}\right]_t$: The ratio $\left[\frac{D_{IG}}{D_{1510}}\right]$ at the moment *t* of UV exposure.

Software of version omnic E.S.P. 5.2a 1992-2000 Nicolet Instrument corporation was used for data collection, processing, and calculation.

The gel fraction and physico mechanical properties of UV cured coatings such as relative hardness, flexibility, gloss at 60 ºC were determined by the methods described in published works [7,12].

3. Results and Discussion

3.1. IR Spectra of Investigated Coatings before and after UV Exposure

IR spectra of BCDE, EBSO, UVI 697 as well as coatings on their base before and after 14.4 s of UV exposure are demonstrated in Fig. 1. Characteristic IR absorption maxima of constituents, investigated coatings and their intensity change after 14.4 s of UV exposure are shown in Table 2.

It can be seen in Fig. 1 and Table 2, after 14.4 s of UV exposure intensity of absorption bands of benzene rings at 1510 cm^{-1}, carbonyl groups at 1730 cm^{-1} and saturated hydrocarbon at 2932 cm^{-1} remained unchanged while absorption bands attributed to TAS (1798 cm^{-1}), total epoxy groups (912 cm^{-1}) and BCDE epoxy (790 cm^{-1}) sharply decreased; absorption bands characteristics for hydroxyl groups (3490 cm^{-1}) and ether groups (1076 cm^{-1}) markedly increased. Therefore, absorption bands at 1798, 912, 3490 and 1076 were used for the quantitative determination of TAS, total epoxy, hydroxyl and ether groups, respectively, by internal standard method; the absorption band at 1510 cm^{-1} (benzene rings) was clear, without any overlap with another absorption bands. So, it was selected as internal reference [5,7,12].

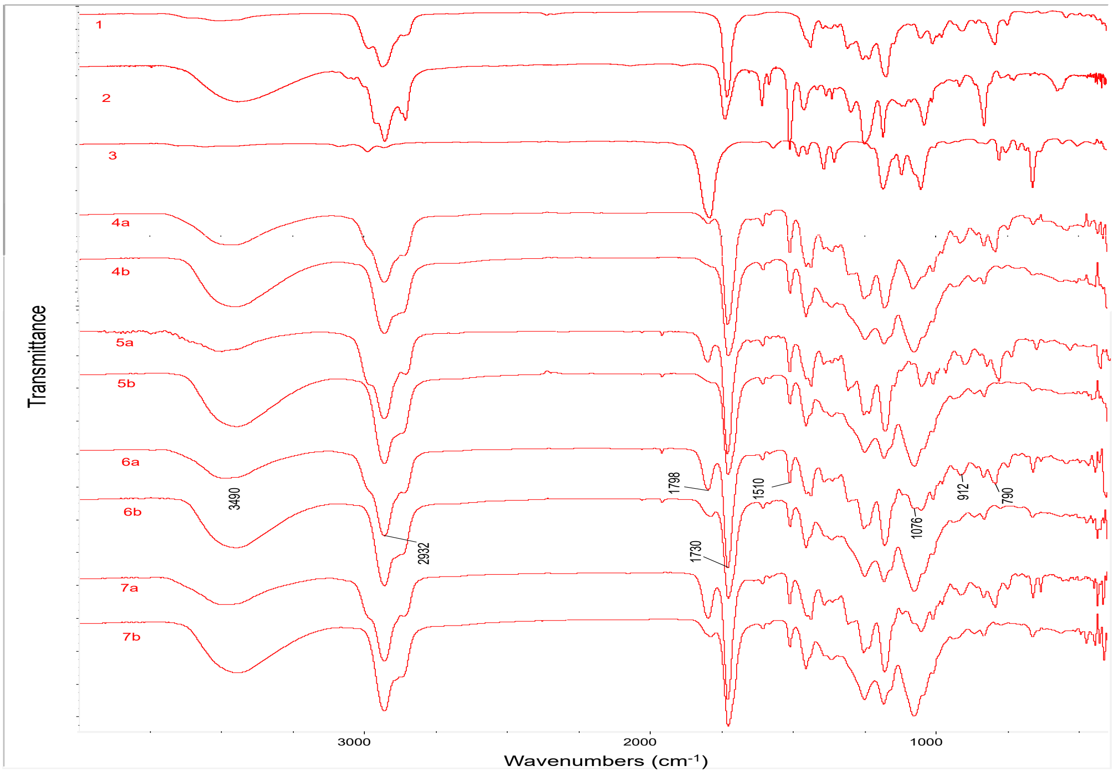


Fig. 1. IR spectra of BCDE (1), EBSO (2), UVI 6974 (3) as well as coatings on their base (4-7) before (a) and after 14.4 s of UV exposure (b). Weight ratio EBSO/BCDE/TAS of coatings 4-7: 4. 20/80/1; 5. 20/80/2.5; 6. 20/80/5; 7. 20/80/7.

Table 2. Characteristic IR absorption maxima of constituents, investigated coatings and their intensity change after 14.4 s of UV exposure

Wave number (cm^{-1})	Vibration	Characteristic IR absorption maxima					**Intensity change**
		BCDE	**EBSO**	**TAS**	Investigated coatings **(BCDE + EBSO +TAS)**		
					Before UV exposure	**After UV exposure**	
3490	OH stretching	-	*	-	*	*	Increased
2932	Saturated CH stretching	*	*	-	*	*	Unchanged
1798	Stretching of aromatic rings in TAS	-	-	*	*	*	Sharply decreased
1730	C=O stretching	*	*	-	*	*	Unchanged
1510	Stretching of aromatic double bonds	-	*	*	*	*	Unchanged
1076	Asymetric C - O - C stretching	-	*	-	*	*	Sharply increased
912	Bending of the rings of epoxy groups in EBSO and BCDE	*	*	-	*	-	Sharply decreased
790	Half ring stretching of epoxy groups in BCDE	*	-	-	*	-	Sharply decreased

(*): Absorption maxima, (-): No absorption maxima

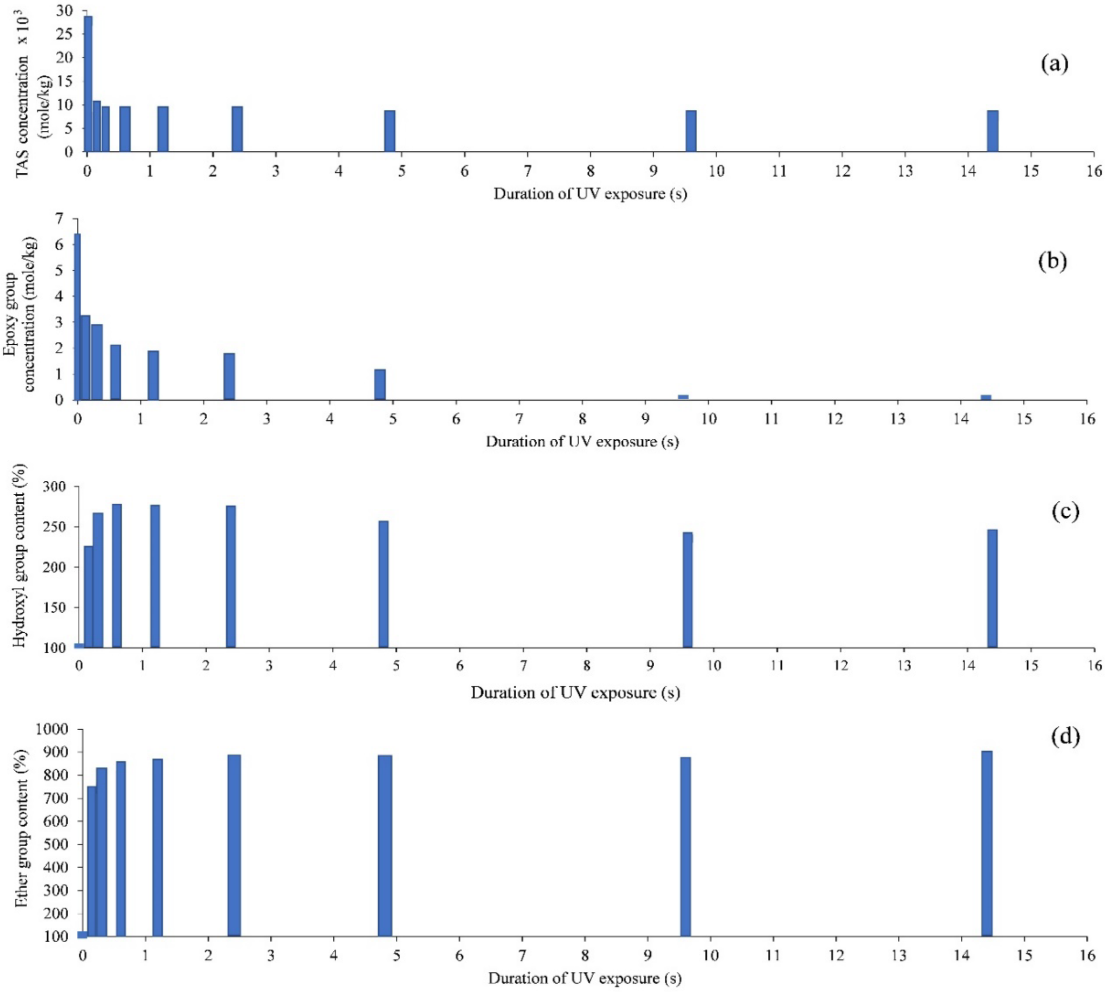


Fig. 2. Change of TAS (a) and epoxy (b), hydroxyl (c), ether groups (d) in the coating EBSO/BCDE/TAS=20/80/5 during UV exposure.

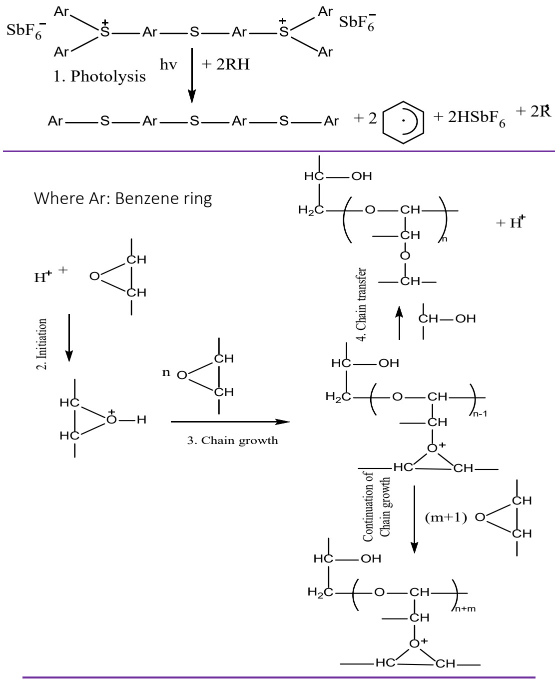
3.2. Change of TAS and Functional Groups in Investigated Coatings during UV Exposure

3.2.1 Change of TAS and functional groups in coating EBSO/BCDE/TAS equal 20/80/5

Variation of TAS and epoxy, hydroxyl, ether groups in coating EBSO/BCDE/TAS equal 20/80/5 during UV exposure is presented in Fig. 2.

As shown in Fig. 2, concentrations of TAS and epoxy, hydroxyl, ether groups were changed very fast in the first 0.15 s, gradually slowed down during time interval from 0.15 to 1.2 s and almost unchanged after 1.2 s of UV exposure. At 14.4 s of UV exposure TAS and epoxy group concentration decreased to 7.5 x 10^{-3} and zero mole/kg, hydroxyl and ether groups increased to 235 and 854%, respectively.

The results presented in Fig. 1 and Fig. 2 are in good agreement with the reported mechanism of cationic photocrosslinking of epoxide compounds (Scheme 1) [2,5,7,8]:



Scheme 1: Mechanism of cationic photocrosslinking of epoxide compounds

As shown in Scheme 1, under UV exposure, in presence of a hydrocarbon compound, TAS is subjected to photolysis producing superacid $HSbF_6$ and some radicals. The protonation of oxygen atoms in epoxy rings by protons of released in the TAS photolysis superacid initiates the cationic ring opening polymerization of epoxy groups, forming hydroxyl and ether groups.

3.2.2. Influence of initial concentrations of TAS in investigated coatings on its photolysis and variation of functional groups during UV exposure

The influence of initial concentrations of TAS in investigated coatings on its photolysis during UV exposure is demonstrated in Fig. 3.

It can be seen from Fig. 3, the concentration of TAS reduced sharply after the first 0.15 s of UV exposure, then was changed insignificantly: The decrease of TAS concentration in coatings having its initial concentrations of 6 x 10^{-3}, 15 x 10^{-3}, 27.8 x 10^{-3}, 37.5 x 10^{-3} after 0.15 s of UV exposure was 3.66 x 10^{-3}, 11.67 x 10^{-3}, 18.07 x 10^{-3}, 27 x 10^{-3} mole/kg, respectively. After 14.4 s of UV exposure the value was 5.04 x 10^{-3}, 13.14 x 10^{-3}, 20 x 10^{-3}, 29.25 x 10^{-3} mole/kg, correspondingly. So, the higher TAS initial concentration in investigated coatings the faster the rate of its photolysis and the higher TAS concentration remained unchanged after 14.4 s of UV exposure.

It can be noticed that the higher TAS initial concentration the more TAS molecules can absorb UV light and be photolysed as soon as the UV irradiation started. Consequently, the higher TAS initial concentration the higher amount of TAS can be photolysised. However, the increase of TAS initial concentration also leads to enhance UV- absorption of the coating because of augmentation of benzene ring concentration of TAS and its photolysis products. This makes TAS molecules in underlayers of the coating unable to obtain enough UV light to be photolysed since they can not move up due to a decrease of mobility in coating during the photocrosslinking. That's why unchanged TAS content is more in coatings with high TAS initial concentration (Fig. 3).

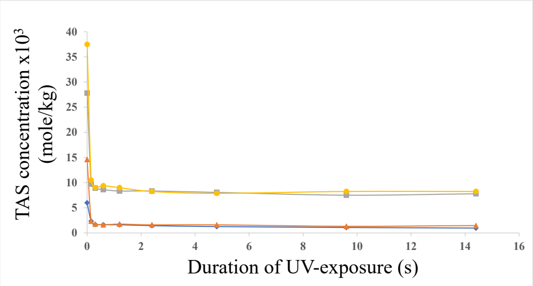


Fig. 3. Influence of initial concentrations of TAS in investigated coatings on its photolysis during UV exposure. Initial concentrations of TAS in investigated coatings (mole/kg): 6 x 10^{-3} (◆), 15 x 10^{-3} (▲), 27.8 x 10^{3} (■), 37.5 x 10^{-3} (●).

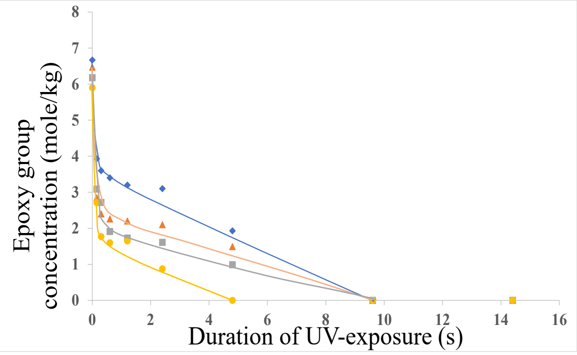


Fig. 4. Influence of initial concentrations of TAS in investigated coatings on the variation of total epoxy group concentration during UV exposure. Initial concentrations of TAS in investigated coatings (mole/kg): 6x10^{-3} (◆), 15x10^{-3} (▲), 27.8x10^{-3} (■), 37.5x10^{-3} (●).

The influence of initial concentrations of TAS in investigated coatings on the variation of the total epoxy group, hydroxyl and ether group concentration during UV exposure is illustrated in Fig. 4, 5 and 6.

As demonstrated in Fig. 4, the total epoxy group concentration diminished very fast in the first 0.15 s of UV exposure. Thereafter, its reduction is gradually slowed down until exhaustion at the duration of UV exposure 4.8s (coating formulation 4) and 9.6 s (coating formulation 1, 2, 3). The diminution of epoxy group concentration in coatings with TAS initial concentrations of 6 x 10^{-3}, 15 x 10^{-3}, 27.8 x 10^{-3}, 37.5 x 10^{-3} mole/kg after 0.15 s of UV exposure was 2.74, 3.09, 3.62, 3.19 mole/kg, respectively. After 4.8 s of UV exposure the value was 4.67, 5.07, 5.18, 5.90 mole/kg, correspondingly. Thus, the higher initial TAS concentration the higher consumption rate of epoxy groups in investigated coatings.

It should be mentioned that epoxy groups are converted in initiation and chain growth reactions (Scheme 1). The higher TAS initial concentration the faster and more TAS is photolysed upon UV-exposure to produce superacid and protons. The process favors initiation reaction and as consequence, chain growth reaction. Therefore, augmentation of initial TAS concentration in investigated coatings increases the conversion rate of epoxy groups during UV exposure (Fig. 4).

It can be noted from Fig. 5 that hydroxyl group contents in coatings having TAS initial concentrations of 6 x 10^{-3}, 15 x 10^{-3}, 27.8 x 10^{-3}, 37.5 x 10^{-3} mole/kg were augmented fast and achieved the highest value 140, 427, 270, 268%, respectively, in exposure time from 0.3 to 1.2 s. Apart from the coating with TAS initial concentration of 6 x 10^{-3} mole/kg, the other had a maximal value of hydroxyl groups during UV exposure.

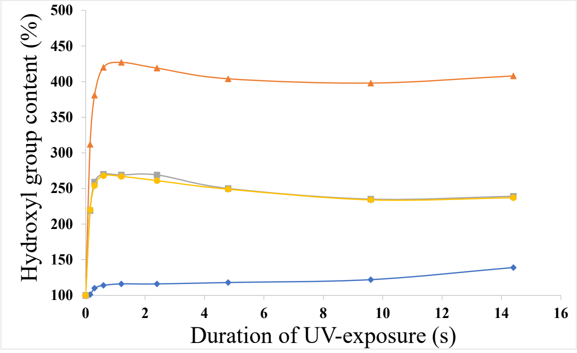


Fig. 5. Influence of initial concentrations of TAS in investigated coatings on the variation of hydroxyl group content during UV exposure. Initial concentrations of TAS in investigated coatings (mole/kg): 6 x 10^{-3} (◆), 15 x 10^{-3} (▲), 27.8 x 10^{-3} (■), 37.5 x 10^{-3} (●).

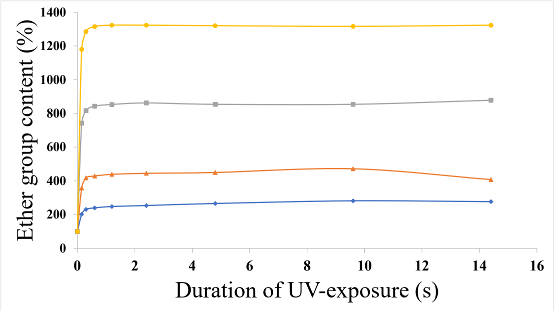


Fig. 6. Influence of initial concentrations of TAS in investigated coatings on the variation of ether group content during UV exposure. Initial concentrations of TAS in investigated coatings (mole/kg): 6 x 10^{-3} (◆), 15 x 10^{-3} (▲), 27.8 x 10^{-3} (■), 37.5 x 10^{-3} (●).

Unlike the variation of hydroxyl group content, the content of ether groups in investigated coatings markedly increased in the first 0.15 s, gradually slowed down in interval from 0.15 to 0.6 s of UV exposure, then changed insignificantly (Fig. 6). Furthermore, the rate of the enhancement of ether groups increased and their maximal contents during UV-exposure were 277, 408, 860, 1323 % for the coatings having TAS initial concentrations of 6 x 10^{-3}, 15 x 10^{-3}, 27.8 x 10^{-3}, 37.5 x 10^{-3} mole/kg. It means, the higher TAS initial concentrations in a coating the higher rate of increase and highest content values of ether groups upon UV exposure.

It can be seen in Scheme 1, while ether groups are formed in both chain growth and chain transfer reactions, hydroxyl groups are produced only in initiation reaction and can be consumed in chain transfer reactions by reaction with growing carbocation. So, the content of hydroxyl groups in investigated coatings during UV exposure is the result of the concurrence of the two opposite reactions. This is the reason for the extreme character of the relationship hydroxyl group content - duration_of UV exposure shown in Fig. 5. Since the increase of initial TAS concentration favors both chain growth and chain transfer reactions, the higher the initial TAS concentration the higher rate of formation of ether groups and their content in investigated coatings (Fig. 6).

3.3. Properties of UV-Cured Coatings

The influence of initial concentrations of TAS in investigated coatings on their gel fraction and relative hardness after 1.2 s of UV exposure is presented in Fig. 7 and Fig. 8.

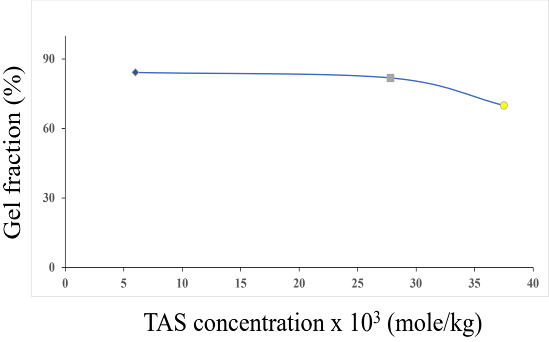


Fig. 7. Influence of initial concentrations of TAS in investigated coatings on their gel fraction after 1.2 s of UV exposure. Initial concentrations of TAS in investigated coatings (mole/kg): 6 x 10^{-3} (◆), 27.8 x 10^{-3} (■), 37.5x10^{-3} (●).

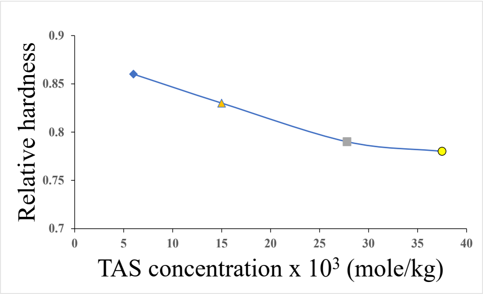


Fig. 8. Influence of initial concentrations of TAS in investigated coatings on relative hardness after 1.2 s of UV exposure. Initial concentrations of TAS in investigated coatings (mole/kg): 6 x 10^{-3} (◆), 15 x 10^{-3} (▲), 27.8 x 10^{-3} (■), 37.5 x 10^{-3} (●).

The figures show that gel fraction and a relative hardness of investigated coatings were slightly reduced after 1.2 s of UV exposure. When initial concentrations of TAS increased from 6 x 10^{-3} to 37.5 x 10^{-3} mole/kg their gel fraction and relative hardness decreased from 84.2 to 69.98% and from 0.86 to 0.76, respectively.

It was determined that flexibility and gloss at 60° of investigated coatings after 1.2 s of UV exposure were 10 mm and 100%, correspondingly.

The obtained results in the study of the influence of initial concentrations of TAS in investigated coatings on their properties indicated that the UV - cured coating with high performance: relative hardness of 0.86, gel fraction of 84.2 %, gloss at 60 ºC of 100% can be made by the use of only 6.10^{-3} mole/kg, a very small concentration of TAS in coating formulation.

Properties of UV-cured investigated coatings depend on many factors resonating or annulling each other like the possibility of constituents of the coatings to participate in a tridimensional polymer network; its crosslinking degree, flexibility, polarity; equal distribution of constituents in coating and smoothness of coating surface etc. The obtained values of the properties of investigated coatings are the result of the effects of the factors.

It should be noticed that TAS was used in the work in the form of UVI 6974 - a mixture of 50% weight of TAS in propylene carbonate. So, increasing TAS concentration in investigated coatings enhances also their concentration of propylene carbonate - a low molecular weight compound that can play the role of a plasticizer and can be extracted by chloroform. This may be a reason for the reduction of gel fraction and the relative hardness of the UV-cured coatings with augmentation of their initial TAS concentration.

The high gloss of investigated coatings might be evidence of the sameness of coating chemical structure as well as the high smoothness of their surfaces.

6. Conclusion

Photocrosslinking of coatings based on TAS, EBSO, BCDE with the weight ratio EBSO/BCDE equal 20/80 is significantly influenced by initial concentration of TAS. An increase of TAS initial concentration from 6×10^{-3} to 37.5×10^{-3} mole/kg led to markedly augmentation of not only rate but also the extent of TAS photolysis, consumption of epoxy groups as well as the formation of ether groups during UV exposure. Unlike ether groups, the relationship between TAS initial concentration and content of hydroxyl groups in the coatings during UV exposure had an extreme character with the highest value in a coating having TAS initial concentration of 15×10^{-3} mole/kg. Gel fraction and the relative hardness of investigated coatings after 1.2 s of UV exposure were slightly reduced, while flexibility and gloss at 60 ºC of the UV-cured coatings remained almost unchanged with the increase of TAS initial concentration.

The investigated coating with TAS initial concentration of 6×10^{-3} mole/kg has highest relative hardness, gel fraction and gloss at 60 ºC of 100% is very perspective for the use as finish layer in high performance coating systems.

Acknowledgments

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