

## STUDY OF ADHESION-COHESION INTERACTIONS BETWEEN POLYMERS IN ADHESIVE COMPOSITIONS

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### STUDY OF ADHESION-COHESION INTERACTIONS BETWEEN POLYMERS IN ADHESIVE COMPOSITIONS

**ABSTRACT.** The results of the research prove that adhesives based on chloroprene rubber can be obtained not only in combination with phenol-formaldehyde resins, but also with other polymers. Selected chlorobutyl rubber (CIIR) and high styrene rubber (KER) proved to be substitutes for phenolic resins, which were used to obtain adhesive compositions with good properties. Despite the existing opinion on the same polarity of the components of the adhesive composition, guaranteeing the most favorable properties, it was shown that compositions with different polarity have all the parameters of quality adhesives. Components with different polarity also show the effect of mutual reinforcement, which determines the alignment, orientation ability of macromolecular chains and occurrence of cohesion and adhesion interactions. The observed textures obtained after mechanical impact proved this claim. Adhesives with more developed textures have better adhesive properties. The selected research methods successfully predict the properties of the components and facilitate their selection and amount.

**KEY WORDS:** adhesives, rubbers, mutual reinforcement, morphology

### STUDIUL INTERACȚIUNILOR DE ADERENȚĂ-COEZIUNE DINTRE POLIMERI ÎN COMPOZIȚIILE ADEZIVE

**REZUMAT.** Rezultatele cercetării demonstrează că adezivii pe bază de cauciuc cloroprenic pot fi obținuți nu numai în combinație cu rășini fenol-formaldehidice, ci și cu alți polimeri. Cauciucul clorobutil (CIIR) și cauciucul cu conținut ridicat de stiren (KER) selectate s-au dovedit a fi înlocuitori pentru rășinile fenolice, care au fost folosite pentru a obține compoziții adezive cu proprietăți bune. În ciuda opiniei existente cu privire la aceeași polaritate a componentelor compoziției adezive, garantând cele mai favorabile proprietăți, s-a demonstrat că și compozițiile cu polaritate diferită au toți parametrii adezivilor de calitate. Componentele cu polaritate diferită arată, de asemenea, efectul de întărire reciprocă, care determină alinierea, capacitatea de orientare a lanțurilor macromoleculare și apariția interacțiunilor de coeziune și aderență. Texturile observate obținute în urma impactului mecanic au dovedit această afirmație. Adezivii cu texturi mai dezvoltate au proprietăți adezive mai bune. Metodele de cercetare selectate pot prevedea cu succes proprietățile componentelor și facilitează selecția și cantitatea acestora.

**CUVINTE CHEIE:** adezivi, cauciucuri, întărire reciprocă, morfologie

### ÉTUDE DES INTERACTIONS D'ADHÉSION ET D'COHÉSION ENTRE LES POLYMÈRES DANS LES COMPOSITIONS ADHÉSIVES

**RÉSUMÉ.** Les résultats de la recherche démontrent que les adhésifs à base de caoutchouc chloroprène peuvent être obtenus non seulement en combinaison avec des résines phénol-formaldéhyde, mais également avec d'autres polymères. Le caoutchouc chlorobutyle (CIIR) et le caoutchouc à haute teneur en styrène (KER) sélectionnés se sont avérés être des substituts aux résines phénoliques, qui ont été utilisées pour obtenir des compositions adhésives avec de bonnes propriétés. Malgré l'opinion existante sur la même polarité des composants de la composition adhésive, garantissant les propriétés les plus favorables, il a été démontré que les compositions de polarité différente possèdent également tous les paramètres des adhésifs de qualité. Les composants de polarité différente montrent également l'effet de renforcement mutuel, qui détermine l'alignement, la capacité à orienter les chaînes macromoléculaires et l'apparition d'interactions de cohésion et d'adhésion. Les textures observées obtenues à partir de l'impact mécanique ont prouvé cette affirmation. Les adhésifs avec des textures plus développées ont de meilleures propriétés adhésives. Des méthodes de recherche sélectionnées peuvent prédire avec succès les propriétés des composants et faciliter leur sélection et leur quantité.

**MOTS CLÉS :** adhésifs, caoutchoucs, renforcement mutuel, morphologie

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## INTRODUCTION

In modern technologies adhesives are used for bonding different materials. The mechanical strength of the adhesive joint is different and depends on the adhesive composition and the type of bonding substrates. There are many combinations of components and modifiers used to improve a number of properties, namely: adhesion, cohesion, heat resistance, cold resistance and others [1-21]. The most widely used compositions are adhesives based on chloroprene rubber (CR). The most commonly used modifiers for this elastomer are phenol-formaldehyde and coumarone-indene resins [10, 11, 21]. Compositions have also been developed involving thermoplastic polymers and elastomers. For example, the adding of a high molecular weight chlorine-containing polymer in CR significantly improves its properties, especially the adhesion of materials based on PVC (polyvinyl chloride), genuine leather, PVA (polyvinyl acetate). Other polymers used are PAM (polyacrylamide), thermoplastic elastomers (styrene-isoprene-styrene). Applications have rubber flour; 1,5-diaminocaproic acid to increase bond strength; nitrooligomers containing a number of polar groups [13, 14]. Different monomers have been grafted onto the CR macromolecules, namely: MMA (metamethylacrylate), SBS (styrene-butadiene-styrene), PVC, PSC (piperylene-styrene copolymer), etc. [8, 15]. Grafting of CR has successfully been processed to enhance the bond strength by using methyl methacrylate monomer [16-18]. The optimal amount of PSC was found to increase the compatibility between the adhesive and the substrate [15]. Despite the rich set of published compositions, there are no sufficiently well-developed theoretical conclusions to predict the probable properties

of the compositions in a given selection of components.

The selection of components, their amount and technological regime is very important for obtaining of adhesives with valuable qualities, as well as the interactions between them. Many polymers are incompatible with each other, but in some cases, this leads to an improvement in a number of properties and mutual reinforcement.

With the present research an attempt has been made to achieve theoretically substantiated results, with which to predict the selection of the components by type and amount and the effect when applying the prepared adhesive composition. Also, to study the orientation effects and interactions between the selected components of the adhesive compositions: chloroprene rubber and chlorobutyl rubber; chloroprene rubber and high styrene resin, to achieve good adhesion properties.

Five types of adhesives-solutions based on chloroprene rubber were used by adding the following polymers (chlorobutyl rubber and high styrene resin, respectively) in different percentage ratios.

## EXPERIMENTAL

### Objects of Investigation

Polychloroprene adhesive solutions are prepared in laboratory conditions, respectively: PCL0; PCL1; PCL2; PCL3; and PCL4 with varying amounts of chlorobutyl rubber (CIIR) and high styrene polymer (KER). The bonding substrates used are samples of vulcanised butadiene styrene rubber with trade name "Duropor".

### Ingredients

The quantities of the used ingredients for rubber compounds are presented in Table 1.

Table 1: Ingredients for rubber compounds

Ingredients, phr	Adhesives code				
	PCL0	PCL1	PCL2	PCL3	PCL4
Chloroprene rubber <b>CR</b> (Baypren 210)	100	100	30	100	100
ZnO	5	5	5	5	5
MgO	4	4	4	4	4
Chlorobutyl rubber <b>CIIR</b> (Lanxness Clorbutyl 1240)		30	100		
High Styrene Rubber (KER 1904)				30	40

*Chloroprene Rubber (CR)*, grade Baypren 210 (LANXESS) [22]: poly(2-chloro-1,3-butadiene), mercaptan modified; of medium crystallization rate;  $\rho=1.23 \text{ g/cm}^3$ ; melting point  $\sim 86 \text{ }^\circ\text{C}$ ;  $T_g \sim -40 \text{ }^\circ\text{C}$ ;  $M_m = 120000$ ; Mooney viscosity UHL(1+4)100 $^\circ\text{C} = 43\pm 4$ .

*Zinc oxide (ZnO)* (Brüggemann): used as a vulcanizing agent for CR [22]. White, solid, powder with particles size  $0.8\div 2.0 \text{ }\mu\text{m}$ , moisture content  $< 0.2 \%$ ;  $\rho=4.9 \text{ g/cm}^3$ .

*Magnesium oxide (MgO)* grade Elastomag 100 (Morton) [22] used as a scorch retarder for adhesives. White, crystalline powder with particles size  $>150 \text{ }\mu\text{m}$ ;  $\rho = 3.2 \text{ g/cm}^3$ ; pH 10.3; BET surface area  $104\text{-}141 \text{ m}^2/\text{g}$ .

*Chlorobutyl Rubber (CIIR)*, grade Clorbutyl 1240 (Lanxness) [22]: colorless, chlorinated isobutylene-isoprene copolymer with low Mooney viscosity UHL(1+4)100 $^\circ\text{C}=38 \pm 4$ ;  $\rho = 0.92 \text{ g/cm}^3$ ; chlorine content 1.25% vol.%.

*High-Styrene Rubber*, grade KER 1904 [22]: high content of 83% bonded styrene in the polymer. It plays an important role as reinforcing agent for rubber. White granulate, non-toxic, odorless; Mooney viscosity ML(1+4)100 $^\circ\text{C}=45\text{-}60$ , Shore hardness  $> 93$ .

Solvents: *Acetone* (Sigma-Aldrich): CAS No 67-64-1, 97%, mol. weight  $58.08 \text{ g/mol}$ ; *Toluene* (Sigma-Aldrich): CAS No 108-88-3, 99.8% anhydrous, mol. weight  $92.14 \text{ g/mol}$ ; *Petroleum benzine* (Merck KGaA): CAS No 64742-49-0, boiling range  $40\text{-}60 \text{ }^\circ\text{C}$ .

## Methods for Preparation of Polychloroprene Adhesives in Laboratory Conditions

### Obtaining the Rubber Compounds on the Mixing Roller

The compounding of rubber components is performed by open laboratory mixing roller with sizes: L/D  $320\times 360$ , revolutions of the slower roll  $25 \text{ min}^{-1}$  and friction 1.27 [23].

About adhesive **PCL0**: first, the chloroprene rubber is plasticized on cold roll for 10 min, then the MgO is added, and finally the ZnO. For the adhesive **PCL1**: chlorobutyl rubber (CIIR) is added after CR and before the metal oxides. About **PCL2**: due to the high content of CIIR, it is first plasticized on the rolls, and then CR, MgO and finally the ZnO are added. About **PCL3** and **PCL4**: due to difficulties in processing the components, a change in the sequence of the ingredients was necessary, i.e., first, the KER is plasticized, the adding of the CR and finally the metal oxides.

### Obtaining Adhesive Solutions

Using direct dissolving methods, the prepared rubber compound is dissolved in the selected solvents. The compound left for swelling in the solution during 24 h. Then the solution is left for stirring in glass flask at 250 rpm for 4 h at room temperature until homogeization was finished [1, 23].

**Adhesive PCL0:** A rubber compound containing: only CR, ZnO and MgO (see Table 1) was used, dissolved in the following solvents in the ratio of acetone: toluene: petroleum benzene = 1:1.1:1.3 with a concentration of 25% [1, 23]. Complete homogenization of the mixture was observed after 4 h.

**Adhesive PCL1:** A rubber compound containing: CR, ZnO, MgO and CIIR (30 phr) was used (Table 1), dissolved in the following solvents in the ratio of acetone: toluene: petrol = 1:1.1:1.3 with concentration of 25%. Complete homogenization of the mixture was also observed after 4 h.

**Adhesive PCL2:** To prepare **PCL2** the same procedure was used as for **PCL1**, the amount of CIIR is 100 phr. The rubber compound was dissolved in toluene at a concentration of 25%. Using the same solvents (acetone, toluene and petroleum benzene), homogenization was very difficult and after 2 h a separation of two phases was observed. The solvent mixture used proved to be unsuitable for the chlorobutyl rubber, and that acetone was a poor solvent for this rubber. The use of toluene alone resulted in complete dissolution of the rubber mixture. No such phenomenon was reported for adhesive PCL1. Probably the CIIR in an amount of 30 phr does not affect the dissolution process in this solvent system.

**Adhesive PCL3:** A rubber compound containing: CR, ZnO and MgO and KER (30 phr) (Table 1) was used, dissolved in the following solvents in the ratio of toluene: petroleum benzene = 3:1 with a concentration of 25%. Without the presence of acetone in the solvent mixture resulted in complete dissolution and homogenization of the adhesive composition after 4 h.

**Adhesive PCL4:** The same procedure was used for the preparation of **PCL4** as for **PCL3**, but the amount of KER is 40 phr. The same solvents were used as for **PCL3**.

After preparation, the adhesives were analyzed [1, 23].

## Methods for Investigation

### *Determination of the Viscosity by Höppler Viscometer*

A Höppler rheoviscometer is used to determine the dynamic viscosity. The viscosity is calculated using the following formula [23]:

$$\eta = k \cdot p \cdot t$$

(1)

$\eta$  – viscosity [cP];  $\kappa$  – constant of relatively tube;

$p$  – shear stress [g/cm<sup>2</sup>];  $t$  – time for passage of the ball [s].

Measurements are made according to standard BDS EN 12092:2003.

### *Optical Microscopy*

A polarization microscope is used for morphological studies [24].

The samples are subjected to mechanical impact by metal blade. In the resulting texture are made repeated measurements with graticule in different areas of its deformation band width ( $d$ ) and total width of the texture ( $L$ ). The ratio between the total width of the deformation texture and the deformation band width is represented by coefficient of mechanical crystallization (CMC) of the adhesive.



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### *Determination of Peel Resistance*

To determine the strength of adhesive joint by peel resistance tests are prepared samples by the same standard material with thickness 2 mm. The adhesive bond strength was measured according to EN 1392:2006 standard. The samples are joined and are pressed and subjected to separation. The disbonding is done on dynamometer at a speed of 100 mm/min. The load (power) is

recorded, causing breaking of the adhesive bond in each of the zones. Then the peel strength [N/mm] of the investigated samples is calculated [23]. Measurements are made according to standard ISO 17708:2018.

## RESULTS AND DISCUSSION

### Determination of the Viscosity of Investigated Adhesives

The data for the rheological measurements of the investigated adhesive compositions are presented in Table 2.

Table 2: Viscosity of investigated adhesives in dependence of the shear stress

Shear stress, [g/cm <sup>2</sup> ]	10	20	30
Viscosity of PCL0, [cP]	2234	2095	1912
Viscosity of PCL1, [cP]	704	667	543
Viscosity of PCL2, [cP]	566	400	314
Viscosity of PCL3, [cP]	465	362	286
Viscosity of PCL4, [cP]	625	495	477

The Table 2 shows that **PCL0** adhesive has the highest viscosity, while the adding of other polymers that are amorphous and lower molecular weight reduces the percentage of crystalline phase in the studied composites. They have a certain plasticizing effect, which reduces the viscosity.

An interesting phenomenon is observed with the adhesives **PCL3** and **PCL4**, in which the high-styrene resin KER participates. When increasing the amount of KER from 30 to 40 phr an increase in viscosity is observed. Not only the viscosity increases, but also the other studied indicators, which are described below in the text. Changes in the properties of the composition are predicted by the theory of reinforcement of polymers [24-26]. According to one of its postulates, when the polymers are incompatible and with excited adhesion, commensurate with the cohesion of the reinforced polymer, come into contact, it

follows the improvement of the properties. In this case, high-styrene rubber (KER), placing its macromolecules in the mass of chloroprene rubber, rearranges its spherulitic structure into a new one with linearly oriented macromolecules, which is composed of associates of the two polymers (KER and CR). In this arrangement, the cohesion and adhesion interaction is improved with an easier orientation option and increased strength under mechanical impacts. This can be seen from the texture of Fig. 8. Increasing the amount of KER increases the total adhesion, which adhesion by 30 phr of KER resin it is still minimal.

### Morphology of the Studied Adhesive Films

The results obtained from the measurement of the coefficient of mechanical crystallization (CMC) are presented in Fig. 1:

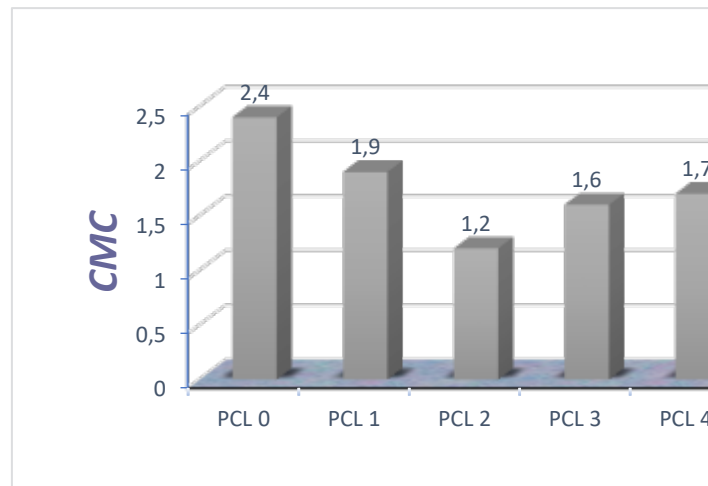


Figure 1. Coefficient of mechanical crystallization (CMC)

From the data it can be concluded that the value of CMC is the highest at **PCL0**, i.e., the adhesive composition is only with chloroprene rubber. When another polymer is introduced into the adhesive composition, which is amorphous, the crystallization of the chloroprene rubber deteriorates and therefore the CMC values are lower (for **PCL1**, **PCL2**, **PCL3** and **PCL4**). The lowest value is for **PCL2**, which is logical, since the participating amorphous polymer (CIIR) is 100 phr and CR is only 30 phr. At the **PCL4** adhesive opposite effect is observed, i.e., the crystallization of the adhesive improves with increasing KER content.

To observe the morphological structure of the polymers individually and in combination in the adhesive compositions, microscopic photographs were taken at 70 and 315 times magnification.

#### *Micrography of Chloroprene Rubber Film /CR/*

Figures 2a and b show optical microscopy images of film from chloroprene rubber (CR) in polarized light, in the undeformed and deformed states, respectively. Under mechanical influence, spherulites turn into fibrils and a very good orientation and crystallization ability of CR is observed. Its macromolecules show a pronounced orientation ability in the direction of impact.

The adding of other polymers impairs the crystallization ability of the rubber. The physicomechanical parameters of **PCL0** show high values of bond strength, but differing in each zone of the bonded samples (non-uniform bonding along the sample length) [27].

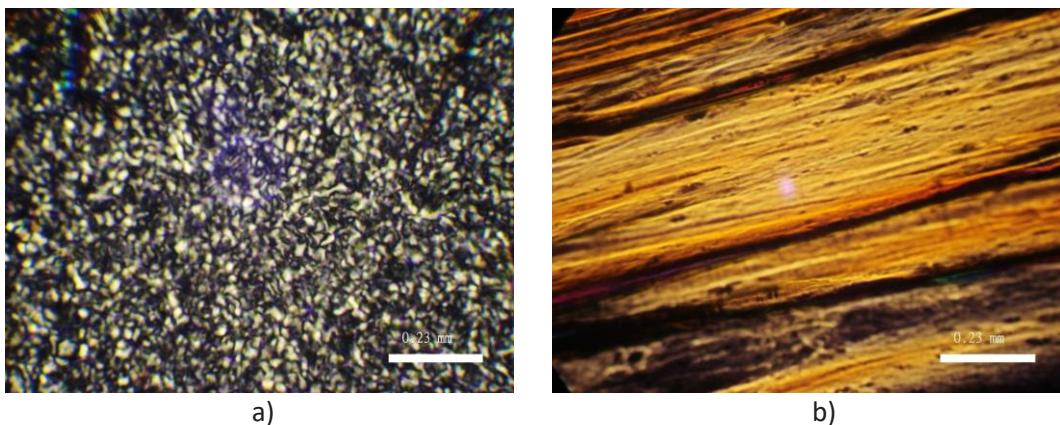


Figure 2. Micrography of adhesive film based on CR (a) in polarized light in undeformed; and (b) deformed state

*Micrography of Chlorobutyl Rubber /CIIR/*

The observed structure of chlorobutyl rubber at room temperature is typically amorphous (Fig. 3). For this reason, the adhesive **PCL2** almost masks the effect of CR crystallization (Fig. 6), as a result of the deteriorating homogeneity of the composition.

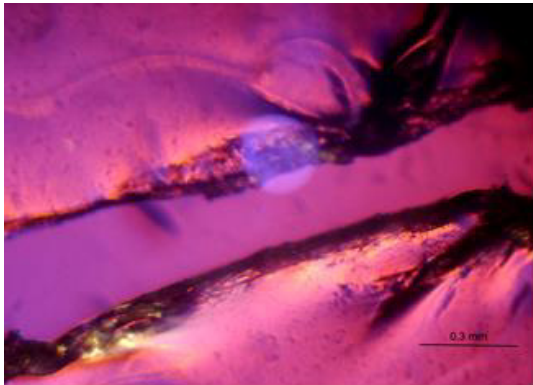


Figure 3. Micrography of Chlorobutyl rubber (CIIR) film in polarized light, after mechanical impact

styrene rubber) and the other phase is styrene.

After mechanical impact the structure is torn, no orientation effects are observed. Cohesion forces are weak, which is the reason for the mechanical impact of the two phases to separate and to obtain unordered zones with undefined composition.

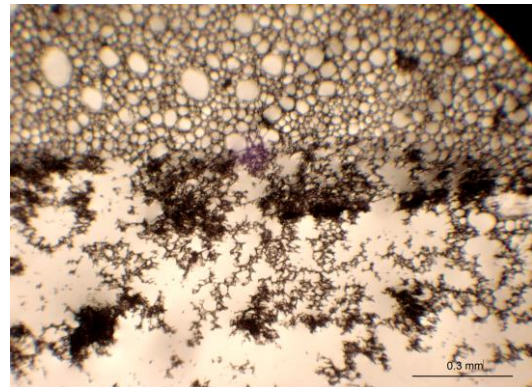


Figure 4. Micrography of High-Styrene Rubber (KER) film in polarized light in deformed and undeformed state

*Micrography of High-Styrene Rubber /KER/*

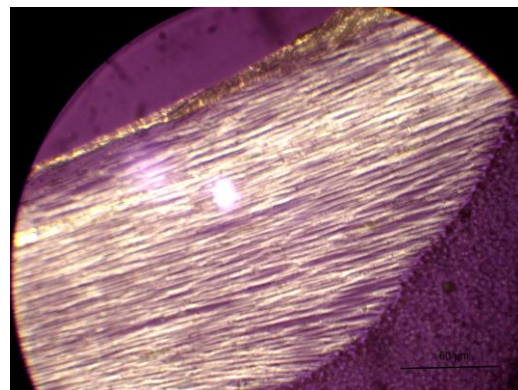
Fig. 4 shows the cellular structure of KER, each cell being composed of two layers: one is a continuous phase of SBR (butadiene

*Polychloroprene Adhesives in the Presence of CIIR and KER Polymers*

The morphological observations of **PCL1** are shown in Fig. 5 a,b.



a)



b)

Figure 5. Micrographs of PCL1 adhesive (100 CR: 30 CIIR) in: a) unpolarized light, b) polarized light, after standing of the film for 72 h

This structure consists of cells composed of the macromolecules of the chloroprene rubber, in which the amorphous

coacervates of the chlorobutyl rubber visible as dark spots are located [24].

Spontaneous crystallization was observed after standing the film during 72 h. Under mechanical impact (Fig. 5b) the texture has pronounced orientation effects and the observed structure is fibrillar. This texture consists of the macromolecules of chloroprene rubber (CR) in result of the recrystallization of spherulites into fibrils. The observed dark elongated zones between the fibrils are the amorphous coacervates of chlorobutyl rubber (CIIR), which are oriented under the influence of chloroprene rubber. The fibrils of CR have a higher density around them (higher percentage of crystallinity). The measured coefficient of mechanical crystallization is 1.9.

Mixing the two incompatible rubbers disrupts the forces of interaction between the macromolecules of each [24, 25]. This happens on the contact surface, where surface stresses occur. Under their influence, amorphous coacervates of CIIR are formed, which are covered by a network of CR. The macromolecules of network formations are in an ordered state. With their presence, these CIIR coacervates stimulate the formation of contact macromolecular formations that are absent in the pure CR (Fig. 2).

In deformation, the pre-arranged structure with increased intermolecular interaction facilitates orientation in fibrils. In this case, it is very likely that CIIR will also show some plasticizing effect to aid orientation. A mutual reinforcement effect is observed, although the two polymers are incompatible [24, 26].

Fig. 6 shows the overmolecular structure of the adhesive film of **PCL2** with composition: chloroprene rubber /CR/- 30 phr and chlorobutyl rubber /CIIR/- 100 phr. It can be seen that CIIR is formed as separate coacervates. Most likely, CIIR coacervates are infiltrated by the CR spherulitic aggregates [24], unlike **PCL1**. Here the continuous phase is CR and the interrupted phase is CIIR, which has crystallized.

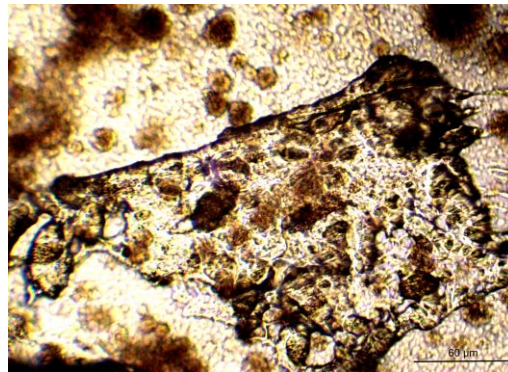


Figure 6. Micrograph of PCL2 (30 CR: 100 CIIR)

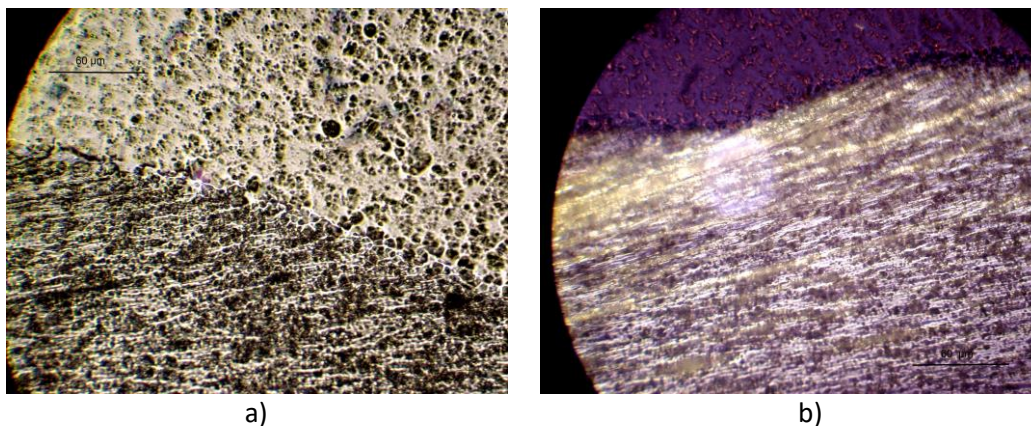
In this adhesive composition, after a film stay of 72h a weak, impaired orientation ability, lack of fibrils was observed. The structure breaks down very easily under mechanical impact. Exceptional amorphization, with insignificant crystalline phase, which decreases during prolonged stay. The coefficient of mechanical crystallization (CMC) is 1.2. The results show that the cohesion forces of the two elastomers exceed the adhesion between them. This composition of the adhesive does not satisfy the requirement of the 6<sup>th</sup> postulate of the reinforcement theory, namely that the adhesion between elastomer and reinforcing agent is commensurate with the cohesion of the reinforced elastomer [25, 26]. Therefore, the obtained values of the adhesive are reduced.

Fig. 7a,b shows the overmolecular structure of adhesive **PCL3** with composition: chloroprene rubber /CR/- 100 phr and high-styrene rubber /KER/- 30 phr. In Fig. 7a, filamentous structures obtained from the orientation effect of CR are observed. Under their influence, the fields of KER have also been oriented. After standing of the film 72h (Fig. 7b), no spontaneous crystallization was observed. But under mechanical impact, the structure passes into a well-defined fibrillar phase. Under the influence of CR, KER polymer also undergoes some orientation. The resulting fibrillar structure shows that CR in combination with KER can induce good mechanical properties of the adhesive



composition. The coefficient of mechanical crystallization is 1.6. This phenomenon proves the mutually reinforcement between

incompatible polymers, where one of them can acquire properties significantly better than those when used as a pure product.



a) unpolarized light and b) polarized light, after a stay of the film 72 h

During the studies, it was found that the amount of KER is a significant factor influencing the properties of the composition. In the amount of 40 phr in **PCL4** the orientation ability of the composition is significantly increased compared to **PCL3**. The effect can be seen in Fig. 8, in which the texture is represented by a compact mass with well-formed fibrils.

crystallization of CR is much more efficient. The coefficient of mechanical crystallization (CMC) is 1.7. As the amount of KER increases to 40 phr, the orientation and crystallization ability increase, and the indicators for bond strength also increase. There is a mutual reinforcement of the two polymers involved in the adhesive mixture, which fully correlates with the strength and rheological data. Therefore, in a certain, optimal amount of KER in such an adhesive composition, the adhesion properties of KER are increased, as opposed to its use alone.

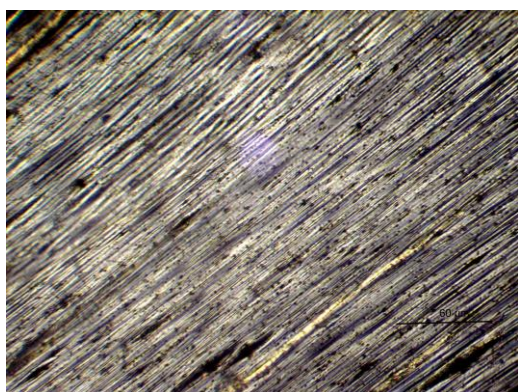


Figure 8. Micrograph of PCL4 (100 CR: 40 KER) in polarized light, stay of the film 72 h

In this adhesive composition, after a stay of the film for 72 hours, completely different structures are observed. CR has crystallized, KER is in the form of amorphous zones. Around the amorphous associates there is a string of crystals, i.e., there the

In conclusion, it can be said that the adhesion properties of materials that do not have good adhesive properties on their own can be used as adhesion activators in combination with other appropriately selected materials. In the resulting compositions, the components mutually reinforce each other under the influence of surface stresses occurring at the interface between the phases. Under their influence, the macromolecular chains change into a linear arrangement with enhanced cohesion and adhesion interactions.

## Results of Determination of Adhesive Bond Strength

To clarify the correlation between rheological tests and microscopic observations, physico-mechanical tests of the five model adhesive compositions studied were performed.

Adhesives were applied with brush as two layers. The open time are 10 min for the first layer and 25 min for second layer. After drying, the samples were activated at 70-80 °C for 10 s. Then samples were pressed at 4 atm for 30 s. The peeling test was done using Dynamometer after 168 h.

The reported results for the bond strength are presented in Fig. 9.

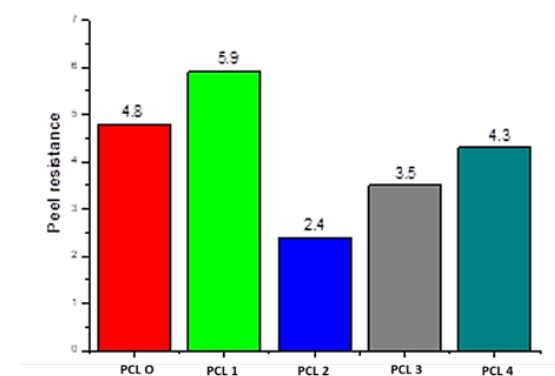


Figure 9. Peel resistance after 168 h

For **PCL1** adhesive, the strength values increase when amount of CIIR is 30 phr. Therefore, this polymer in such a concentration can completely replace the widely used phenol-formaldehyde resin.

The adhesive properties of **PCL2** deteriorate sharply compared to **PCL1**. The CIIR polymer is in a too large amount (100 phr) and reduces adhesion. This adhesive differs from the others by its low initial adhesion, which property is suitable for its use for auxiliary bonding of internal shoe details (linings, soles, insoles, etc).

When using KER in an amount of 30 phr (at **PCL3**) in an adhesive composition deteriorates the physico-mechanical properties of the bond strength compared to

**PCL0**. Increasing the amount of KER (**PCL4**) improves the strength values, which fully correlates with the microscopic observations of the mutual reinforcement of the two polymers.

## CONCLUSIONS

The possibility of obtaining adhesive compositions based on chloroprene rubber (CR) in combination with polymers that have not been used for this purpose, namely chlorobutyl rubber (CIIR) and high styrene polymer (KER), has been proven.

It was found that the properties of the studied model adhesives depend on the amount of components in the adhesive, influencing their cohesion and adhesion interactions in the adhesive composition.

It has been proven that adhesive compositions can have good properties in combination of polar (CR) and non-polar (KER) components.

The use of the method of optical microscopy for determining the mechanical crystallization facilitates the selection of components for adhesive compositions and can be used to predict the properties of adhesives.

It has been confirmed that the compatibility of the polymers used in the model adhesive compositions is not a decisive factor in obtaining good adhesion properties of the bonded compounds. The improvement is due to the reinforcing effect of one polymer relative to the other.

## Acknowledgment

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