Article

Effect of Micromolecules and Macromolecules on the Environmentally Friendly Impregnation Solution for High-Performance Rubber Composites Compared with Traditional RFL Impregnation

Zhihao Shi 1,2, Hongwei He 1,2,*, Pengfeng Wu 1,2, Zeguang Yang 1,2, Wenwen Yu 1,2, Fuyong Liu 1,2, Fengbo Zhu 1,2, Zhiyi Zhang 1,3 and Qiang Zheng 1,4,*

1 College of Materials Science & Engineering, Taiyuan University of Technology, Taiyuan 030024, China; zhangzhiyi@tyut.edu.cn (Z.Z.)
2 Key Laboratory of Interface Science and Engineering in Advanced Materials, Ministry of Education, Taiyuan University of Technology, Taiyuan 030024, China
3 Shanxi-Zheda Institute of Advanced Materials and Chemical Engineering, Taiyuan 030001, China
4 Ministry of Education Key Laboratory of Macromolecular Synthesis and Functionalization, Department of Polymer Science and Engineering, Zhejiang University, Hangzhou 310027, China
* Correspondence: hehongwei4103@126.com (H.H.); zhengqiang@zju.edu.cn (Q.Z.)

Abstract: In this paper, a novel resorcinol-formaldehyde-free and environmentally friendly adhesives for polyester (PET) fiber impregnation treatment were compounded successfully. First, a network structure was formed by reacting micromolecular and water-soluble glycerol triglycidyl ether (GLTE) and triethylenetetramine (TETA). Then, this was mixed with latex in order to prepare an impregnation solution glycerol triglycidyl ether-triethylenetetramine-butyropyridine latex system (GTL), which can replace the toxic components (resorcinol and formaldehyde) of the resorcinol-formaldehyde-latex (RFL) impregnation system. Similarly, the macromolecular epoxy resin E-51-triethylenetetramine-butyropyridine latex system (ETL) and the traditional RFL impregnation system were also prepared in order to compare with the GTL. Further, the reaction conditions of the impregnation system, the surface chemical composition and interfacial properties were characterized by differential scanning calorimetry (DSC), Fourier transform infrared spectroscopy (FTIR) and peeling strength, respectively. The results showed that the peeling adhesion performance between the GTL-modified PET fabric and the rubber (38.5% higher than that of the ETL impregnation solution) was comparable to that of the RFL impregnation system because of micromolecular and more active GLTE. This study provides new insights into the interface design of PET/rubber composites and will facilitate the development of PET/rubber composites.

Keywords: environmental; PET fabrics; impregnation solution; interfacial adhesion; peeling strength

1. Introduction

Polyester (PET) fiber has high breaking strength, high elastic modulus and high resistance to creep elongation. At the same time, its composites have strong thermal stability, good heat resistance and corrosion resistance and other excellent properties [1–3]. Fiber is the main stress-bearing layer of rubber products and is widely used in strengthening rubber or resin matrices, such as tires, conveyor belts or other fields [4]. It improves the performance of rubber composites and plays a very important role in the development of the rubber industry [5,6]. The performance of rubber products depends on the fibers and matrix. Due to the large difference between the polarity and modulus of the synthetic fibers and the rubber matrix, the fibers and the matrix are chemically and physically incompatible with each other [7]. Similarly, the polyester fibers are crucial for the performance of rubber composites [8]. Effective interfacial adhesion between polyester fabric and rubber can make
stress transfer more efficiently, and even determine the safety and service life of composites in applications. The good news is that some active functional groups, such as -NH2, -OH, -SH and -COOH, have been used to modify the surface of the fabric by nitration, reduction and so on. The above groups can help to strengthen adhesion between the fabrics and the matrix [9,10].

At present, many efforts have been made to modify fiber surfaces, aiming to improve the interfacial interaction between the fibers and the rubber matrix. Examples include plasma treatment, electron beam, gamma irradiation, UV initiated grafting, chemical grafting and coating methods [11–25]. However, physical treatment methods, such as plasma treatment and γ-ray irradiation, not only require strict equipment and processing conditions, but also have a high cost. In addition, the traditional surface chemical grafting and etching treatments seriously impair the overall mechanical properties of the fibers. Therefore, there is an urgent need to develop a simple, efficient and cost-effective strategy for fiber surface modification.

The impregnation system for PET fibers has made great progress in recent years. The most commonly used impregnation system at present is resorcinol-formaldehyde-latex (RFL) [26]. RFL is composed of a continuous RF resin phase and latex particles. The RF resin can be chemically linked on the fiber surface because of the many hydroxyls and hydroxymethyl groups in the RF phase. Then, the latex particles can strengthen the bond to RF and rubber when the vulcanization reaction occurs, participating in the reaction and forming a cross-linked network structure [27]. Although the RFL impregnation system is quite mature and effective for PET, it is toxic and formaldehyde has been reclassified as a 1B carcinogen according to the US Environmental Protection Agency (EPA) Chemical Abstracts. There is an urgent need to develop a new type of environmentally friendly impregnation system to replace the toxic RFL with the increasing environmental protection requirements.

In the literature, there are many studies on environmentally friendly impregnation systems that do not use resorcinol and formaldehyde [27–30]. We also explored a simple method to modify PET fabric without toxic substances [31]. However, there are few reports that systematically compare the performance of different impregnation solutions. By studying the commonalities and differences between different environmentally friendly impregnation systems and RFL, significant guidance on the adhesion between polyester fibers and rubber substrates may result.

Thus, two different environmentally friendly impregnation systems were prepared in our research, and the traditional and toxic RFL impregnation system was also used for comparison. The interfacial adhesion, reaction time, chemical composition and surface morphology of different impregnation systems were investigated, and a new environmentally friendly impregnation system with a simple preparation process was developed.

2. Experimental Section

2.1. Materials

The PET fabrics used in this study were purchased from Anhui Huaye Special Materials Co., Ltd., Wuhu, China. Glycerol triglycidyl ether (GLTE) and epoxy resin E-51 was bought from Shanghai Mclean Biochemical Technology Co., Ltd., Shanghai, China. The chemical structures of GLTE and E-51 are shown in Figure 1. Triethylenetetramine (TETA) were obtained from Tianjin Fuchen Chemical Reagent Co., Ltd., Tianjin, China. Vinlypyridine latex (40%) was purchased from Zibo Zeyang Chemical Co., Ltd., Zibo, China. Styrene-butadiene rubber (SBR, ESBR 1502, styrene/butadiene (23/77 of mass ratio)) was supplied by Sinopec Qilu Co., Ltd., Zibo, China, and nature rubber (NR, 1-0082) was from Yunnan Agricultural Reclamation Group Co., Ltd., Kunming, China. Carbon black N330 was purchased from Kabote Investment Co., Ltd., Shanghai, China. Aromatic oil (VIVATEC 500) was supplied by the Hansen & Rosenthal Group, Ningbo, China. The adhesive agents, RA and RS, were obtained from Jiangsu national Huagong Technology Co., Ltd., Nanjing, China. ZnO was supplied by Liuzhou Zinc Products Co., Ltd., Liuzhou,
China. The accelerator was supplied by Qingdao Kangan Rubber Technical Co., Ltd., Qingdao, China. Anhydrous ethanol was obtained from Tianjin Tianli Chemical Reagent Co., Ltd., Tianjin, China. All the chemical reagents were used without any further purification.

![GLTE](image1)

**Figure 1.** Chemical structures of GLTE and E-51.

2.2. Preparation of Different Impregnation Solutions

First, 5 g of GLTE and 2 g of TETA were mixed and stirred at 60 °C for 40 min. Subsequently, 100 g of vinyl-pyridine latex was added to the above adhesive solution and stirred for 2 h at a speed of 600 rpms. Finally, the GLTE/TETA-Latex (GTL) impregnation solution was synthesized.

Similarly, the epoxy resin E-51/TETA-Latex (ETL) impregnation solution was also prepared using the same method.

The resorcinol-formaldehyde-latex (RFL) impregnation solution was made as follows: Sodium hydroxide was dissolved in deionized water and stirred for 5 min at 25 °C. Then, resorcinol and formaldehyde were added and stirred until resorcinol completely dissolved. These reagents were reacted for 6 h in order to obtain the pre-condensed phenolic (RF) resin solution. Subsequently, vinyl-pyridine latex was mixed with the above RF resin solution, stirred and aged for 20 h at room temperature. Finally, the pH value was adjusted to 8~9 by adding an appropriate amount of ammonia water.

2.3. Impregnated PET Fabrics with Different Impregnation Solutions

The PET fabric was fully immersed into the three kinds of impregnation solutions at room temperature. Then, the excess impregnation solution was extruded out into beakers using a rolling stainless-steel rod. Then, these fabrics were dried at 110 °C for 20 min and cured at 200 °C for 3 min. In this paper, we call the PET fabrics coated with GTL, ETL and RFL as PET-GTL, PET-ETL and PET-RFL, respectively.

2.4. Preparation of PET/Rubber Composites with Different Impregnation Solutions

The sample preparation is outlined in Figure 2 and the formula of the rubber mixture was used in Table 1 in our study. The rubber mixture was rolled in a mixing roll into sheets with a thickness of 2 mm. Then, it was cut into pieces of equal size to the PET fabrics. Finally, The PET fabrics were laid on the two sheets of rubber to avoid wrinkling, and the uncured fabric/rubber composites were installed into a 23 × 23 × 10 cm³ stainless steel mold and vulcanized at 150 °C for 40 min under 15 MPa.
Table 1. The rubber compound composition.

<table>
<thead>
<tr>
<th>Component</th>
<th>Content (phr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NR</td>
<td>30</td>
</tr>
<tr>
<td>SBR1502</td>
<td>70</td>
</tr>
<tr>
<td>Zinc oxide</td>
<td>5</td>
</tr>
<tr>
<td>Stearic acid</td>
<td>2</td>
</tr>
<tr>
<td>Carbon black N330</td>
<td>30</td>
</tr>
<tr>
<td>Antioxidant (4010NA)</td>
<td>1.5</td>
</tr>
<tr>
<td>Aromatic oil 840</td>
<td>15</td>
</tr>
<tr>
<td>Silica</td>
<td>15</td>
</tr>
<tr>
<td>2,4,6-Tri [double (methoxy methyl) amino]-1,3,5-triazine (RA)</td>
<td>1.5</td>
</tr>
<tr>
<td>Compound of resorcinol and stearic acid (RS)</td>
<td>1.5</td>
</tr>
<tr>
<td>N-Cyclohexyl-2-truxene thiazole sulfonamide (CZ)</td>
<td>4</td>
</tr>
<tr>
<td>Coumarone resin</td>
<td>10</td>
</tr>
<tr>
<td>Sulfur</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>186.5</td>
</tr>
</tbody>
</table>

2.5. Characterization

Attenuated Total Reflection Fourier transform infrared spectroscopy (ATR-FTIR, INVENIO-S, BRUKER, USA) was used to characterize the changes in the chemical composition and the chemical structure of the fiber surface in the mid infrared region (4000–5000 cm\(^{-1}\)).

Non-isothermal differential scanning calorimetry (DSC) was performed in 30–200 °C at a heating rate of 10 °C/min using a NETZSCH-204F1 differential Scanning calorimeter analyzer from Germany. The isothermal DSC was applied by raising the temperature to 60 °C at 10 °C/min and was then kept at 60 °C for 100 min. All the experiments were carried out under a nitrogen atmosphere. The DSC thermal spectra were evaluated to investigate optimal experimental conditions for the preparation of impregnated solutions.

The morphology of the composites was examined by a scanning electron microscope (SEM) (GEMINISEM 360, Carl Zeiss, Jena, Germany) equipped with an energy dispersive spectrometer (EDS) (Xplore 30, London, UK) detector. The fractured surfaces of the vulcanized composite were sputter-coated with gold prior to analysis. The SEM measurements were performed at an accelerating voltage of 5 kV and the SEM-EDS tests were carried out at 20 kV.

The preparation of 180° peeling specimens and peeling strength tests were based on ASTM D413-98. The interface adhesion of PET-EDL fabrics/rubber composites was
measured by a 180° peeling strength test at a peeling speed of 50 mm/min on an electronic tensile testing machine (UTM5504, SUNS, China). Strip samples that were 250 mm long and 25 mm wide were prepared. Each measurement was repeated at least 10 times, and then the average value was calculated.

3. Results and Discussion

3.1. Reaction Conditions of GLTE/TETA and E-51/TETA

The DSC test was significant for guiding the preparation and storage of GLTE/TETA (GT) adhesives. The non-isothermal DSC curve of the curing reaction of the GT adhesives is shown in Figure 3a. The curing reaction was exothermic, and the reaction between GLTE and TETA started at about 60 °C. The reaction heat peak of the GT adhesives appeared at 91 °C, indicating the reaction rate was the highest. Therefore, the aging and storage temperature of the GT adhesives in the experiment was about 60 °C. Correspondingly, the isothermal DSC was kept at 60 °C for 100 min. As shown in Figure 3b, the exothermic reaction in the isothermal DSC basically continued for about 40 min. Thus, the process parameters for preparing the GT adhesive in our study were determined as less than 60 °C for 40 min to produce a water-soluble adhesive with low cross-linking density. The GT adhesive prepared by the above process parameters was used to modify the PET fabric surface, which can be further cured during the next co-vulcanization process. Similarly, the non-isothermal curve of the E-51/TETA (ET) adhesive is shown in Figure 3c. The curing reaction of the ET adhesive was exothermic and the reaction started at around 60 °C. In the isothermal DSC (Figure 3d), the reaction exothermic peak basically disappeared after about 40 min, which indicated that the ET adhesive reaction was almost complete when it was held at 60 °C for about 40 min. Thus, the process parameters for preparing ET adhesive in our study were also determined as less than 60 °C for 40 min to produce a controlled cross-linking density.

Figure 3. (a) The non-isothermal DSC curve of the GT adhesive; (b) the isothermal DSC curve of the GT adhesive; (c) the non-isothermal DSC curve of the ET adhesive; and (d) the isothermal DSC curve of the ET adhesive.
RFL has been used as an impregnation solution for PET fabrics for a long time. The RFL consists of a continuous RF resin phase and latex particles dispersed in a cross-linked network structure of RF resin. RF resin is made by the reaction of resorcinol and formaldehyde. Up to now, many scholars have conducted research on the preparation of RF resin by the polymerization of resorcinol-formaldehyde resin, showing that the synthesis of RF resin is quite toxic and environmentally unfriendly [32]. Thus, the GTL impregnation solution was developed by us. Not only is the preparation process environmentally friendly, but it is also simple and convenient compared with the traditional RFL impregnation solution.

3.2. Chemical Composition of PET Fabric Surface

The vulcanization reaction of the uncured fabric/rubber composites is an extremely complicated process due to the numerous components in the rubber mixture. Take the system of the PET-GTL/rubber composites as an example. The possible schematic diagram of the chemical interactions between PET-GTL and rubber is shown in Figure 4. Epoxy groups could be considered as reactive sites with TETA and open to create chemical bonds on the fiber surface. The VP-latex particles can be distributed in the above GT adhesives uniformly and form the GTL impregnation solution. Lastly, PET-GTL and an all rubber mixture can undergo a co-vulcanization reaction, resulting in an interpenetrating network and excellent interfacial adhesion between the fabrics and rubber.

![Figure 4. Possible schematic diagram of the chemical interactions between PET-GTL and rubber.](image)

The surface chemical structure changes of the fabrics impregnated with three different impregnation solutions were investigated by ATR-FTIR measurements in the infrared region (4000–5000 cm⁻¹). Figure 5 illustrates the ATR-FTIR spectra of PET-GTL fabrics, PET-ETL fabrics, PET fabrics and PET-RFL fabrics. For the PET-GTL fabrics, compared with the PET fabrics, it was observed that a new bandwidth around 3382 cm⁻¹ and a new absorption peak at 1590 cm⁻¹ occurred, which was due to the introduction of amine groups in the GT adhesives. The absorption peak at 1254 cm⁻¹ and the newly introduced absorption peaks at 910 cm⁻¹ and 853 cm⁻¹ are attributed to the symmetric stretching vibration and asymmetric stretching vibration of the epoxy ring, respectively. This indicates that the GT adhesive still contained the epoxy groups after the heat treatment of the fabrics. In addition, we can see from the figure that two new absorption peaks appeared, located at 3075 cm⁻¹ and 1643 cm⁻¹. The two new absorption peaks correspond to the symmetric stretching vibration of C-H and the stretching vibration of C=O in C=O, respectively, which shows that the vinylpyridine latex successfully adhered to the surface of the PET.
fabrics. There are two very sharp absorption peaks near 2918 cm$^{-1}$ and 2847 cm$^{-1}$, which are the antisymmetric tensile vibration absorption peaks of C-H.

![ATR−FTIR spectra](image)

**Figure 5.** ATR−FTIR spectra of PET-GTL fabrics, PET-ETL fabrics, PET fabrics and PET-RFL fabrics.

### 3.3. Peeling Strength of PET/Rubber Composites Impregnated by GTL, ETL and RFL Impregnation Solutions

Figure 6 shows the peeling strength of the PET fabrics/rubber composites impregnated with GTL, ETL and RFL. In this study, we prepared a new environmentally friendly impregnation solution, GTL. The peeling strength of the PET fabrics/rubber composites impregnated with the new environmentally friendly impregnation solution, GTL, reached a comparable level to that of the PET fabrics/rubber composites treated with RFL. At the same time, the peeling strength of the GTL impregnation solution was 38.5% higher than that of the ETL impregnation solution. The difference between them may be due to the fact that epoxy resin E-51 is a macromolecular compound and does not have better water solubility. It is also shown that the water-soluble epoxy compound GLTE with small molecules is more suitable for the preparation of environmentally friendly impregnation solutions.

![Peeling strength](image)

**Figure 6.** Peeling strength of PET-GTL/rubber, PET-ETL/rubber and PET-RFL/rubber composites.
3.4. Interfacial Adhesion Mechanism of Fabrics/Rubber Composites

Figure 7 shows the SEM of the fabrics and the fabric/rubber composites with different fabric treatments. The PET fabrics, after they were impregnated by GTL, ETL and RFL impregnation solution, are shown in Figure 7(a1–c1). A thin and uniform coating layer formed and the fibers have clear boundaries with each other after the PET fabrics were impregnated, especially for PET-GTL and PET-RFL, as shown in Figure 7(a1,c1), revealing that GTL and RFL have excellent permeability and compatibility with the fabrics. However, a relatively thick (even some large aggregates) and continuous layer occurred and the fibers have blurry boundaries with each other after the PET fabrics were impregnated by the ETL impregnation solution (Figure 7(b1)), which also shows why incompatibility between the PET-ETL and the rubber matrix was detected (Figure 7(b2)). This is because the non-polar and weak water-soluble epoxy compound E-51 has poor wettability to PET fabrics, which may be the reason for the poor adhesion to rubber. Comparing the SEM images after peeling of the fabrics/rubber composites (Figure 7(a2–c2)), we can see that the PET fabrics cladding a layer after GTL and RFL impregnation treatment were more closely bonded to the rubber matrix and the gaps were filled with rubber matrix (Figure 7(a2,c2)). However, the gaps between the ETL-PET fabrics and the rubber were broad and little rubber adhered to the fabrics (Figure 7(b2)), indicating that the ETL cladding layer and the rubber have a poor wettability with each other. The GTL impregnation solution eliminates the incompatibility of polyester fabrics with rubber substrates. The rubber and the fabric adhere to each other by forming an interface between the PET fabric and the rubber. The resin functional groups in the GTL impregnation solution are attached to the polar groups of the fabric, whereas the latex groups are attached to the rubber matrix through co-vulcanization, thereby forming a rubber–fabric composite structure.

Interestingly, we can find the phenomenon that the images of the treated fabrics and fabric/rubber composites are completely opposite, as compared in three figures (Figure 7(a1–c1,a2–c2)). Take Figure 7(b1,b2) as an example. A relatively thick and continuous layer on the fabric (Figure 7(b1)) did not contribute to strong interfacial adhesion, as mentioned above in Figure 6. As shown in Figure 7(b2), broad gaps between the ETL-PET fabrics formed and the fabrics were so smooth that it was rare for the rubber to adhere to the fabrics after the peeling failure of the PET-ETL/rubber composites.

In this study, sulfur migration during vulcanization was investigated by SEM-EDS. The impregnation layers were completely free of sulfur before PET-GTL, PET-ETL and PET-RFL were co-vulcanized with the rubber matrix, which obviously comes from the vulcanizing agent in the rubber mixture. Figure 8(a1–c1,a2–c2) represent the EDS images of the PET fabric/rubber composite interface treated by GTL, ETL and RFL impregnation solutions, respectively. From the figures, we can see that sulfur migrates from the rubber to the impregnation layer. The sulfur migration in the PET fabric/rubber composites impregnated with GTL and RFL was more pronounced than that in the PET fabric/rubber composites impregnated with ETL, resulting in a more uniform distribution of the sulfur element at the interface, as shown in the red ellipses in Figure 8(a2,c2). It can make GTL and RFL have a larger crosslink density than that of ETL during the vulcanization process. Sulfur migrates from the rubber matrix into the impregnated layer during vulcanization. The reaction between GTL and the rubber matrix is achieved by co-vulcanization due to the migration of the vulcanizing agent from the rubber into the impregnation layer. However, E-51 has inactive points because it has less reactive sites and non-polarity. The reaction between ETL and rubber is inadequate, showing little sulfur migration to the interface and the fabric bulks, as shown in the red ellipse in Figure 8(b2). Obviously, the non-polar and weakly water-soluble epoxy compound E-51 has poor wettability to PET fabrics. These results are consistent with Figures 6 and 7.

The schematic diagram of the curing network structure of the micromolecular GTL system and the macromolecular ETL system is shown in Figure 9. GLTE is trifunctional (three epoxy groups per molecule) and has a short molecular chain; however, E-51 is difunctional (two epoxy groups per molecule) and has a long molecular chain, as can be
seen in Figure 1. Thus, the number of reactive sites of GLTE is more than that of E-51. With an increase in the content of the micromolecular epoxy-type GLTE, the cross-linking density is increased, so a more compact cross-linking network is formed. The dense curing network structure leads to high strength, so the peeling strength of the GTL system as an impregnation solution for PET is higher than that of the ETL system. However, the long chain of E-51 molecules with large steric hindrance can lead to a decrease in the crosslink density of the ETL system when the macromolecular epoxy E-51 reacts with an amine curing agent. So, the influence of the impregnation solution on the interface adhesion of PET/rubber composites is very low, inducing weak interfacial action between PET and rubber.

Figure 7. SEM images of the PET fabrics and fabric/rubber composites with different treatments of fabrics: (a1–c1) PET fabrics impregnated with GTL (PET-GTL), ETL (PET-ETL) and RFL (PET-RFL); (a2–c2) PET fabric/rubber composites treated with GTL, ETL and RFL after peeling failure.
Figure 9. Schematic diagram of the curing network structure of (a) the micromolecular GTL system and (b) the macromolecular ETL system.

4. Conclusions

In this work, in order to avoid the use of toxic resorcinol and formaldehyde, a new environmentally friendly impregnation system (GTL) based on GLTE and TETA was developed, and the GTL impregnation solution was found to achieve an equivalent bonding effect to that of the traditional RFL impregnation solution. At the same time, we prepared two new environmentally friendly impregnation systems in order to explore and compare the adhesion mechanism of environmentally friendly impregnation systems prepared by macromolecular and small molecule compounds. When the weight ratio of GLTE/TETA is 5:2, the peel strength of PET-GTL/rubber composites can reach 16.5 N/mm, which is very close to that of PET-RFL/rubber composites. We have shown that the new environmentally

Figure 8. (a1–c1) EDS images of PET fabric/rubber composite cross-sections treated by GTL, ETL and RFL. (a2–c2) Sulfur element distribution on cross-sections of PET fabric/rubber composites treated with GTL, ETL and RFL impregnation solutions.
friendly GTL impregnation system forms a uniform coating on the surface of the PET, which is conducive to good interfacial bonding. The vulcanizing agent can migrate from the rubber to the GTL layer, enhancing the adhesion between the GTL and the rubber. The study of the interfacial bonding mechanism may have a significant impact on the fundamental research and engineering applications of composite materials. It is a promising way to replace the RFL dipping method that is used in the industry. In all, the GTL impregnation system is an environmentally friendly and effective way to improve the interfacial adhesion performance of PET fabrics and rubber.

Author Contributions: Conceptualization, Z.S., H.H. and Q.Z.; methodology, P.W. and Z.Y.; validation, W.Y.; writing—original draft preparation, H.H.; writing—review and editing, H.H.; supervision, F.L., Z.Z. and F.Z.; project administration, Q.Z. All authors have read and agreed to the published version of the manuscript.

Funding: This work is supported by the Natural Science Foundation of Shanxi Province (Grant No. 202103021224102), the Fund for Shanxi “1331 Project”, “New polymer functional materials” industry-university-research innovation platform (Grant No. DC2100000856), the Key Research and Development (R&D) Projects of Shanxi Province (Grant No. 20210204021011) and the Shanxi-Zheda Institute of Advanced Materials and Chemical Engineering (Grant No. 2022SX-TD022).

Conflicts of Interest: The authors declare no conflict of interest.

References
31. He, H.; Wu, P.; Yang, Z.; Shi, Z.; Yu, W.; Liu, F.; Zhu, F.; Zheng, Q.; Zhang, D.; Li, S. A facile way to modify polyester fabric to enhance the adhesion behavior to rubber. *Coatings* 2022, 12, 1344. [CrossRef]

**Disclaimer/Publisher’s Note:** The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.