

ADHESION CAPABILITY OF ECO-EPOXY ADHESIVES SYNTHESIZED BY THE ADDITION OF MODIFIED TANNIC ACID



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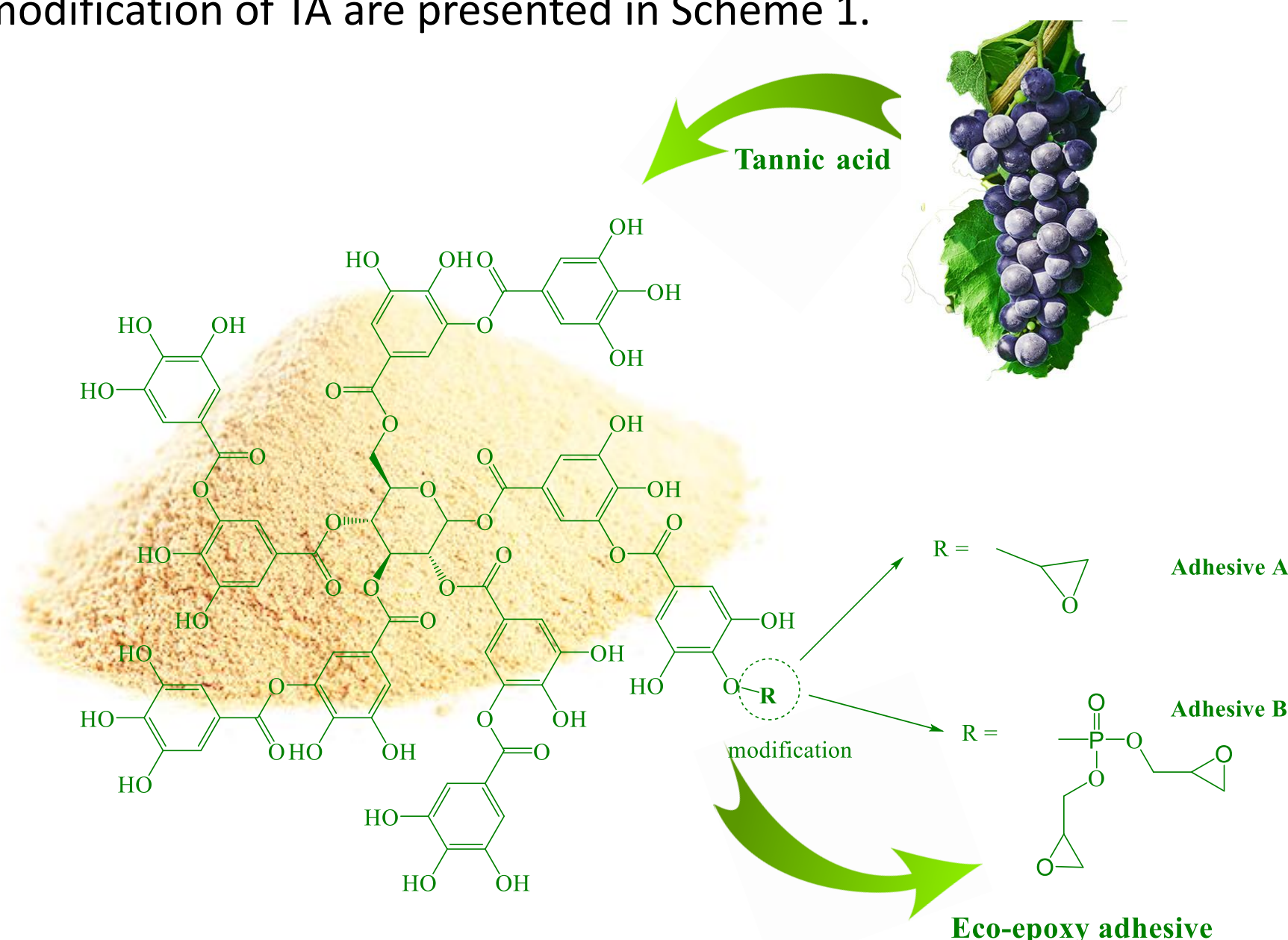
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Introduction

The aim of this study is to investigate the interface adhesion of novel eco-epoxy adhesives by the addition of two types of modified tannic acid: (A) glycidyl ether and (B) glycidyl phosphate ester of TA, which are used as a bio-based replacement of the BPA-based epoxy component. The majority of structural epoxy adhesives, used in aerospace, contain a BPA component, and thus the adhesion effects were analyzed on two different substrates: aluminum (Al) and carbon fiber reinforced polymer (CFRP), which are used for lightweight structures. Methods used for characterization were the microhardness testing method, the bell peel test (BPT), and microstructural analysis of fractured surfaces. In addition, proving that the microhardness testing method of the interface adhesion is a reliable and fast testing method will enable its use as qualitative indicator in adhesive selection.

TA modification

The chemical structure of both types of adhesive components obtained by the modification of TA are presented in Scheme 1.



Scheme 1. Chemical structure of modified tannic acid for the aim of obtaining eco-epoxy components

Results and discussion

Figure 1 shows the values of the adhesion parameter b as a function of the replaced epoxy BPA component. An increase of the adhesion parameter b with the increase of TA content indicated an increase of adhesion with Al adherend. The adhesion parameter b , for adhesive B with 15 wt.% of replacement, was 41.6% higher than for adhesive A and 153.4% higher than the REF.

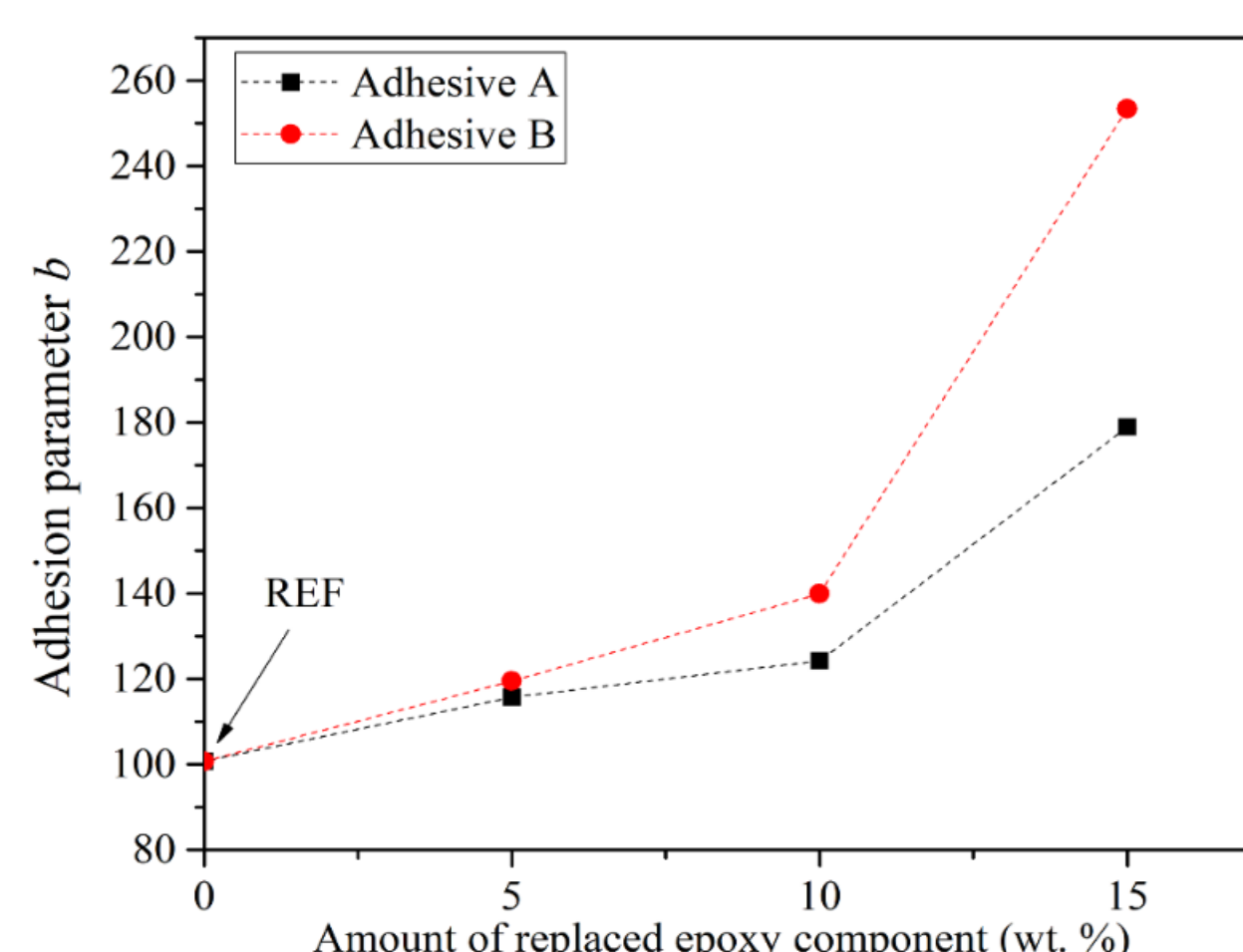


Figure 1. Adhesion parameter b determined using the Chen–Gao model [1,2]

A consequence of the increase in the peel load of adhesive B was the higher percentage of CF than for REF and A. Adhesive B showed slightly different fracture behavior. Two regions of unstable forces can be noticed, which are related to the higher percentage of CF and to the crack, jumping from the interface to within the adhesive and vice-versa.

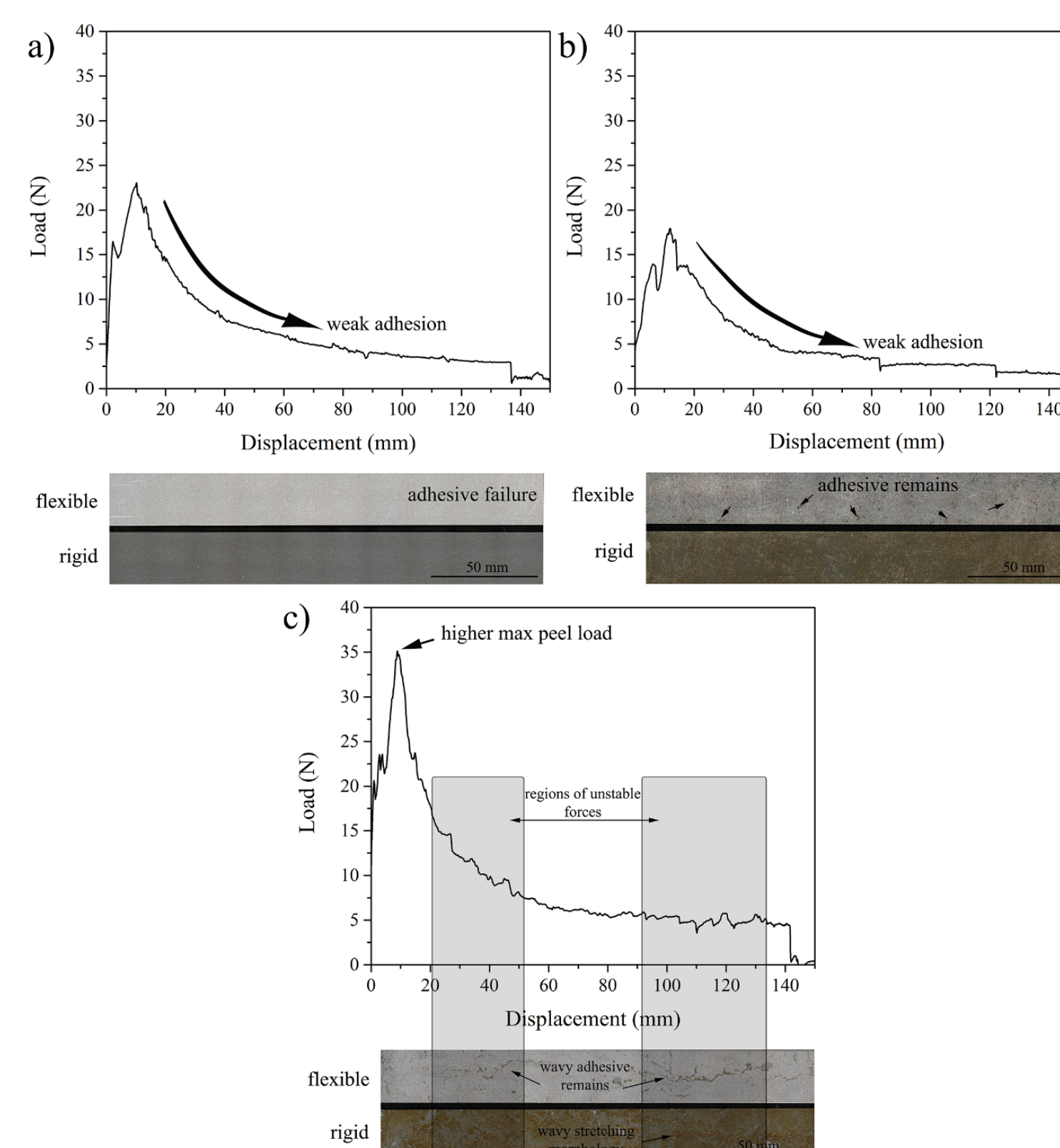


Figure 2. Examples of load–displacement graphs of the bell peel test (BPT) on Al for adhesives a) REF, b) A, and c) B

The obtained results from Figure 3 indicated that the fast and easy method for assessment of the adhesion quality, using the adhesion parameter b , may be used to predict the differences between the selected adhesives for the same adherend material.

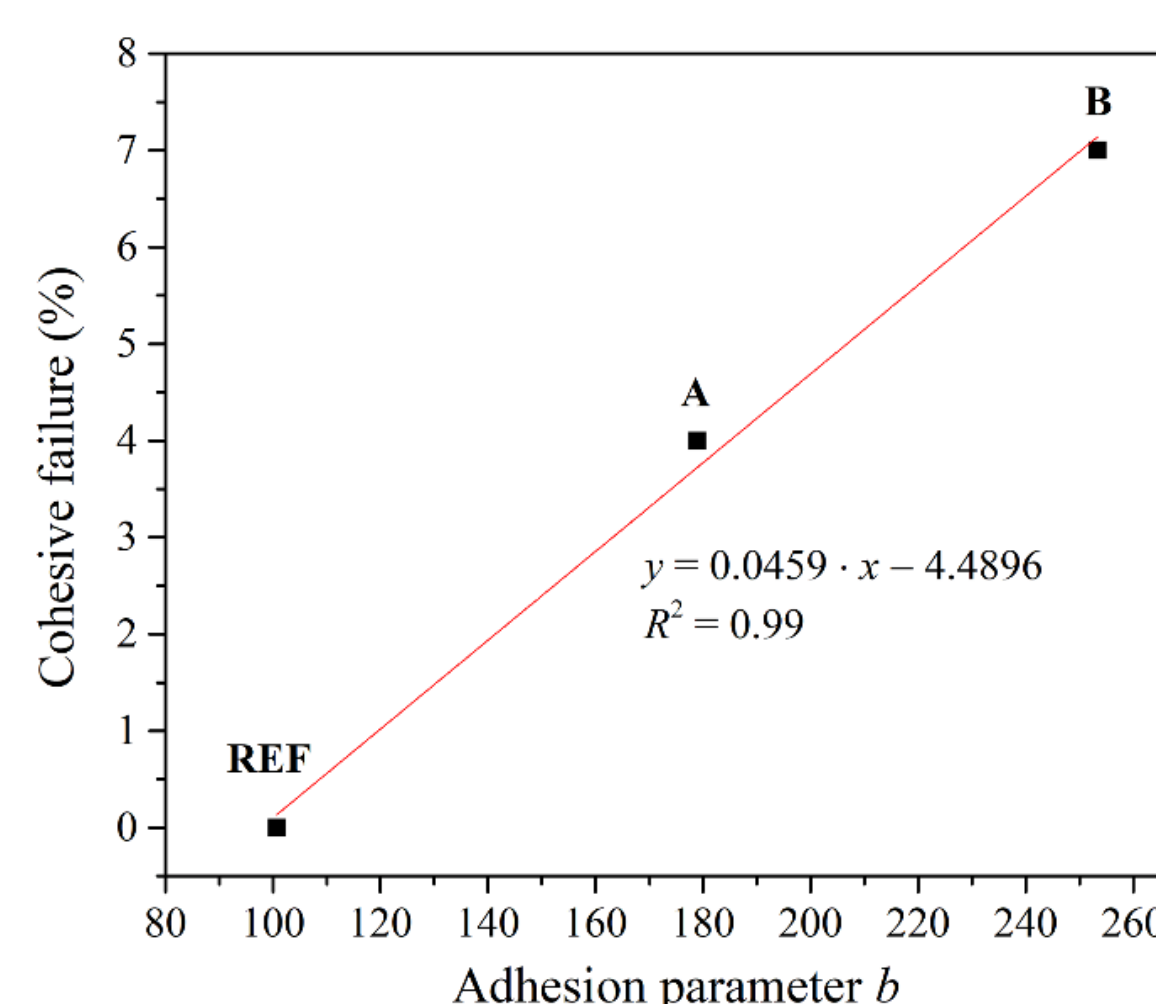


Figure 3. Correlation between the cohesive failure and the adhesion parameter b for adhesives REF, A, and B on Al adherends

Conclusions

The synthesized epoxy ester phosphate derivate of TA (adhesive B) showed enhanced interfacial adhesion on both Al and CFRP, and their high potential as a replacement of the BPA component (DGEBA) was emphasized. Industrial application of obtained eco-epoxy adhesives might consider bonding of secondary/non-structural elements of lightweight structures.

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References

- [1] Chen, M.; Gao, J. *Mod. Phys. Lett. B* 2000, 14, 103–108,
[2] Tomić, N.; Saleh, M.N.; Teixeira de Freitas, S.; Živković, A.; Vuksanović, M.; Poulis, J.A.; Marinković, A. *Polymers* 2020, 12, 1541.