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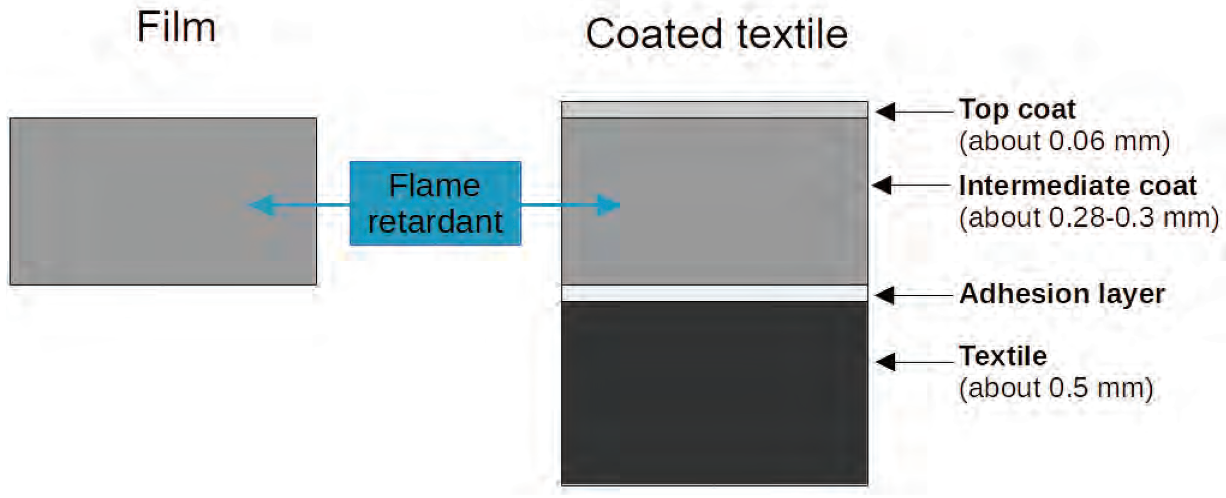
COMMERCIAL AND BIOBASED HALOGEN-FREE FLAME RETARDANTS FOR THIN POLYURETHANE MATERIALS USED FOR TEXTILE COATINGS

Background

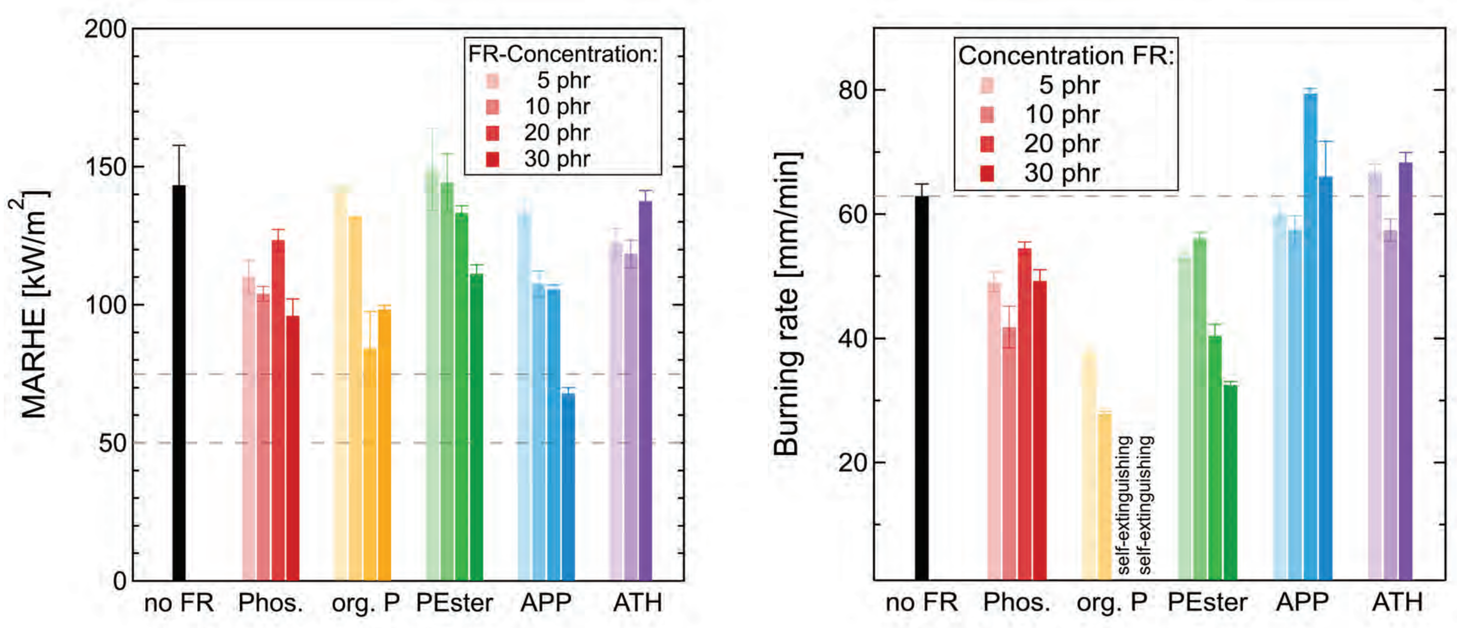
Polyurethane (PUR) is a versatile polymer to produce e.g. coated fabrics for furniture and interior of cars, trains and cruiser ships. But also in public buildings like hotels, restaurants and hospitals it´s ubiquitous. Since PUR is easily flammable, flame retardants (FR) are necessary. Effective FR used in the past are based on halogenated compounds which are subject to increasingly severe restrictions. Alternatives are needed. These are e.g. FR based on phosphorous and/or nitrogen compounds or aluminium hydroxide (ATH). These compounds are usually developed for bulk materials and show an insufficient effect regarding fire safety in thin films. Furthermore, FR incorporated in thin films show a completely different fire protection performance than the same FR incorporated in the functional layer of a coated textile. Therefore, 16 commercial FR were used, combined and their concentration varied to proof their efficacy. Furthermore three biogenic residuals (starch, keratin and bark) were modified to be applied as FR in flexible, thin PUR materials.



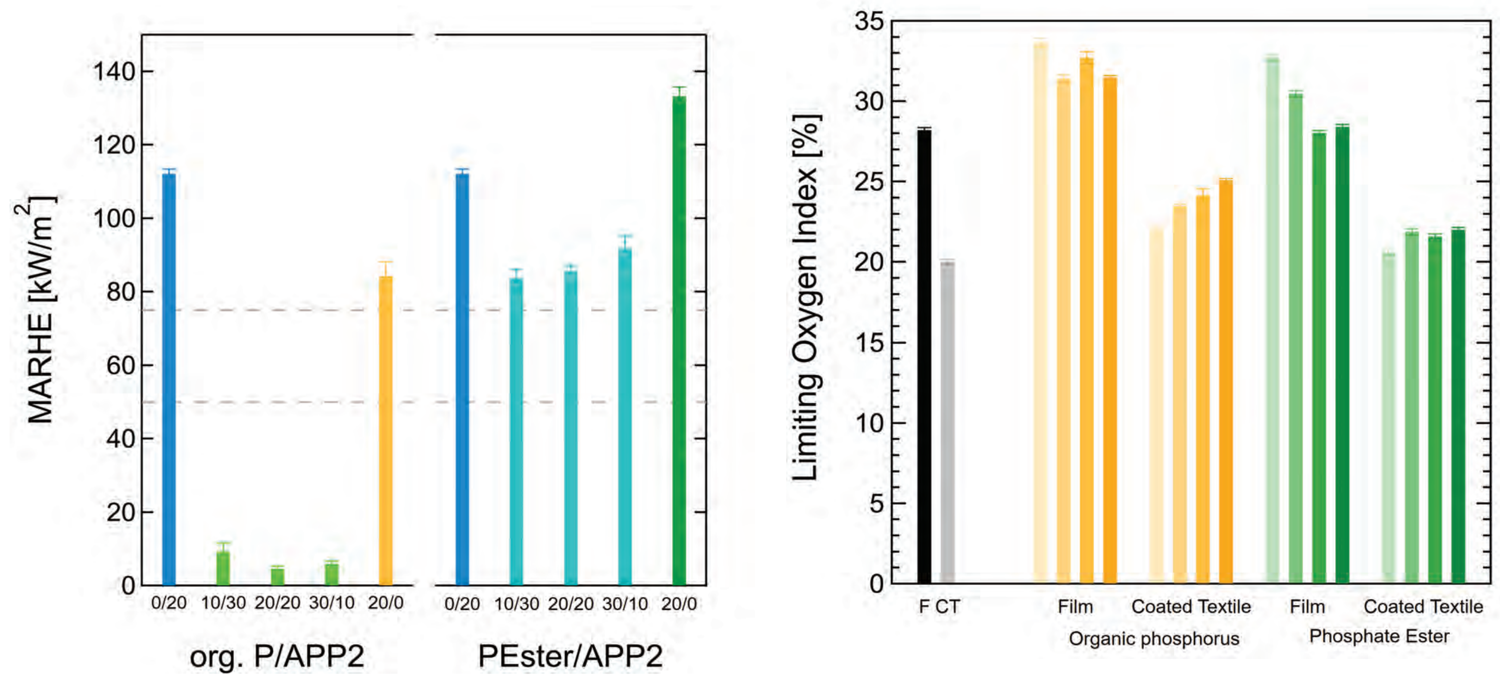
Structure of a PUR-film and coated textile. Flame retardant is included in intermediate layer.

Commercial Flame Retardants[a]

Five commercial flame retardants with various chemical structures were incorporated in films and coated textiles: phosphate, organic phosphorus compound, phosphate ester, ammonium polyphosphate (APP) and ATH. Flame retardants were used in various concentrations and combined in several ratios. A reference material without FR was made as well. Samples were analysed with cone calorimetry, horizontal and vertical burning behaviour and limiting oxygen index.



Cone calorimetric (left) and horizontal burning test (right) results of coated textile with five different flame retardants with four concentrations.



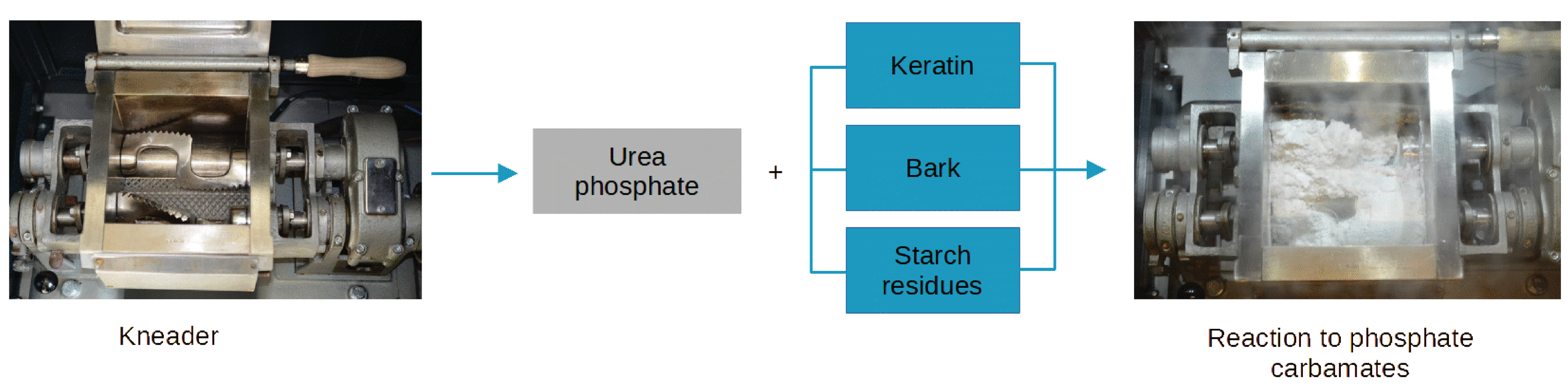
Left: Combination of two different flame retardants in several ratios. Right: Comparative cone calorimetric results of films and coated textiles with the same composition.

- Higher FR concentrations led to better flame retardancy in some cases (for coated textiles with FR 2 and FR 3).
- Methods gave complementary information since analysing different properties: heat production and flame propagation.
- Coated textiles with organic phosphates are self-extinguishing.

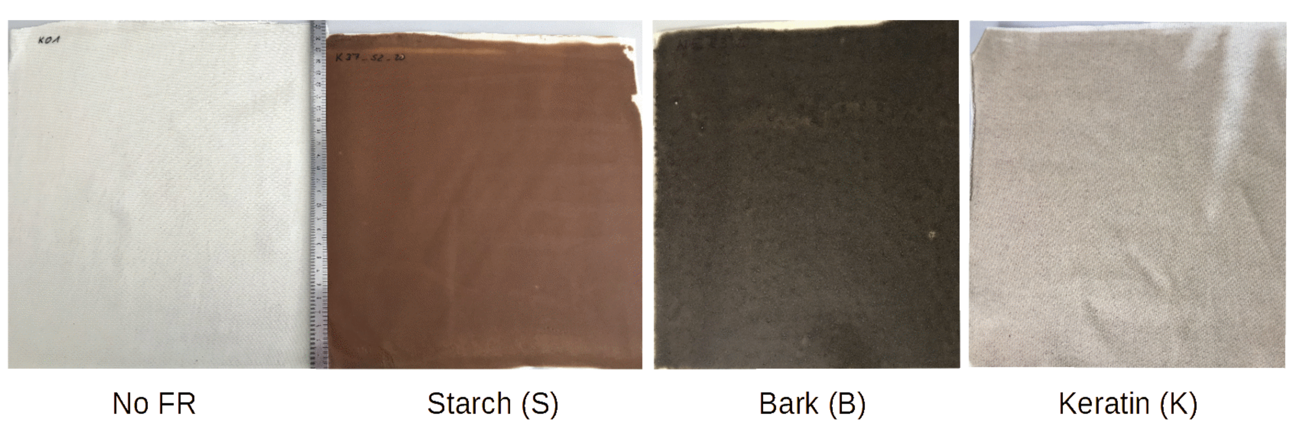
- Combination of two FR led to enhanced flame retardancy.
- Improvement of flame resistance depends on the choice of FR in the mixture.
- Burning behavior of coated textiles cannot be predicted from the testing results of the films.

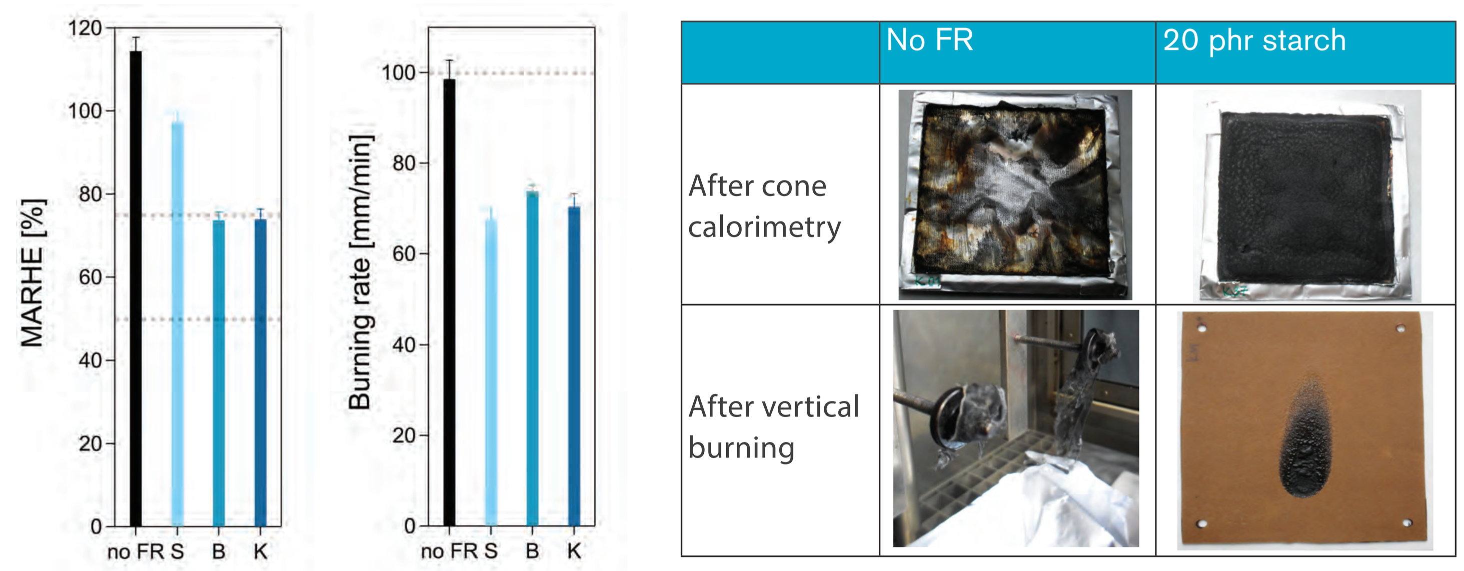
Flame Retardants based on biogenic Residues

Biogenic residues were modified with urea phosphates. The enrichment of the compounds with amine and phosphate functionalities improved the flame retardancy. Obtained powders were incorporated in the intermediate layer of a coated textile and afterwards analysed with cone calorimetry, tests of horizontal and vertical burning behaviour and limiting oxygen index.



- All residues (keratin, bark, starch) could be modified and enriched in phosphate.
- All powders could be incorporated in PUR coated textiles with at least 20 phr, mostly with increasing the paste viscosity.





Cone calorimetric (left) and horizontal burning test (middle) results of coated textiles with different modified biogenic residues as flame retardant (S – starch, B - bark, K – keratin). Visual comparison of coated textiles without FR and with 20 phr modified starch on the right side.

- All modified residues showed a flame retardant effect – decreased burning rates and MARHE-values as well as self-extinguishing behaviour in vertical burning tests.
- Intumescence layer occurred for several samples

Conclusions

→ Enhancement of flame retardancy of thin, polymeric compounds with selected commercial FR feasible.
→ Higher concentrations do not always lead to better flame retardancy.
→ Mixtures of FR are the most effective.
→ No prediction of behaviour of coated textiles by means of film results.

→ All residues could be modified via the phosphate carbamate reaction and incorporated in coated textile.
→ All modified biogenic residues showed flame retardant effect → decreased burning rates and MARHE-values, self-extinguishing properties in vertical burning tests and increased LOI.
→ Intumescent layers were formed.

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IPHC

References

[a]M.Bader, M. Lehmann, M. Meyer, Thin and flexible polyurethane composits: study about halogen-free flame retardants (in progress)

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