Enhancing Flame-Retardant Properties in Waterborne Polyurethane Dispersions for Automotive Interior Parts

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challenges&backround

- **Waterborne polyurethane dispersions (WPUD) have low flame-retardant properties by default.**
- **Flame retardancy is a critical challenge in automotive applications.**
- **Halogen-based flame retardants are hazardous (toxic gases, pollutants)**

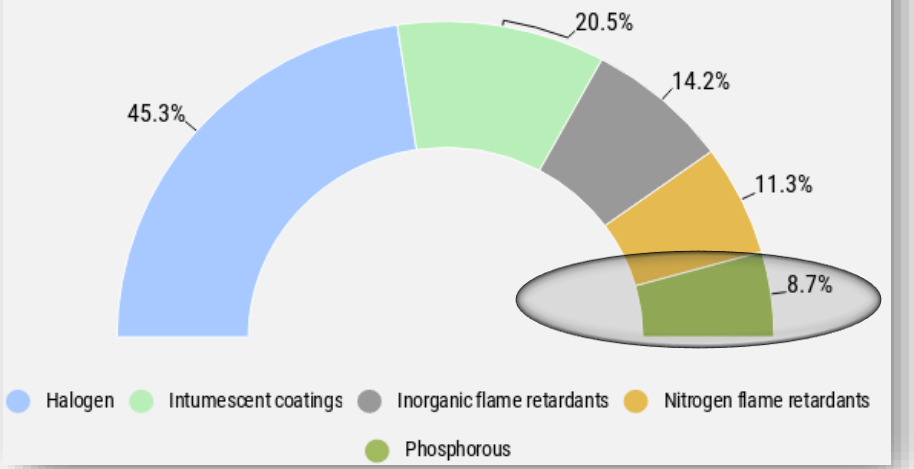
market

Halogen
Largest segment in 2028

Phosphorous
Best performing segment between 2023 and 2028

Inorganic flame retardants
Slowest growth segment between 2023 and 2028

Segment share (%) 2023

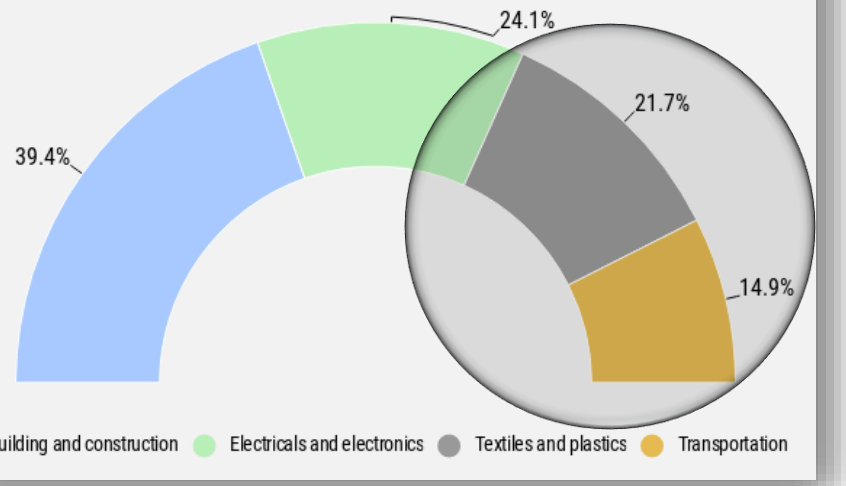


Building and construction
Largest segment in 2028

Electricals and electronics
Best performing segment between 2023 and 2028

Building and construction
Slowest growth segment between 2023 and 2028

Segment share (%) 2023



improvement&new solutions

- **Phosphorus-based flame retardants selected to enhance safety**
- **These compounds form phosphoric acid during combustion, trapping radicals and creating a protective layer.**

PO• + H• → HPO

PO• + OH• → HPO2

HPO + H• → H2 + PO•

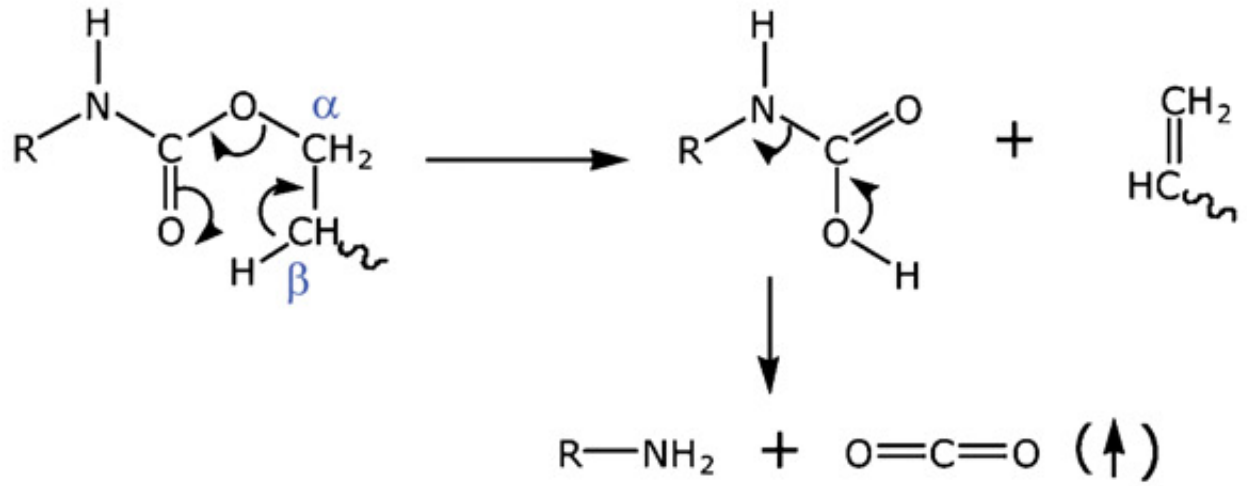
OH• + H2+ PO• r→ H2O + HPO

HPO2• + H• → H2O + PO

HPO2• + H• → H2 + PO2

HPO2• + OH• → H2O + PO2

chemistry behind it



Thermal degradation profile for an urethane bond-supposed mechanism

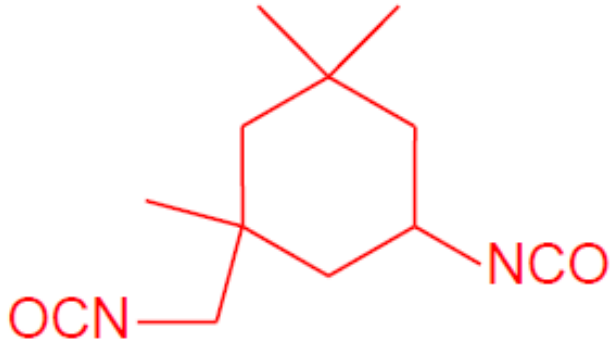
D.K. Chattopadhyay, D.C. Webster / Progress in Polymer Science 34 (2009) 1068–1133

chemistry behind it

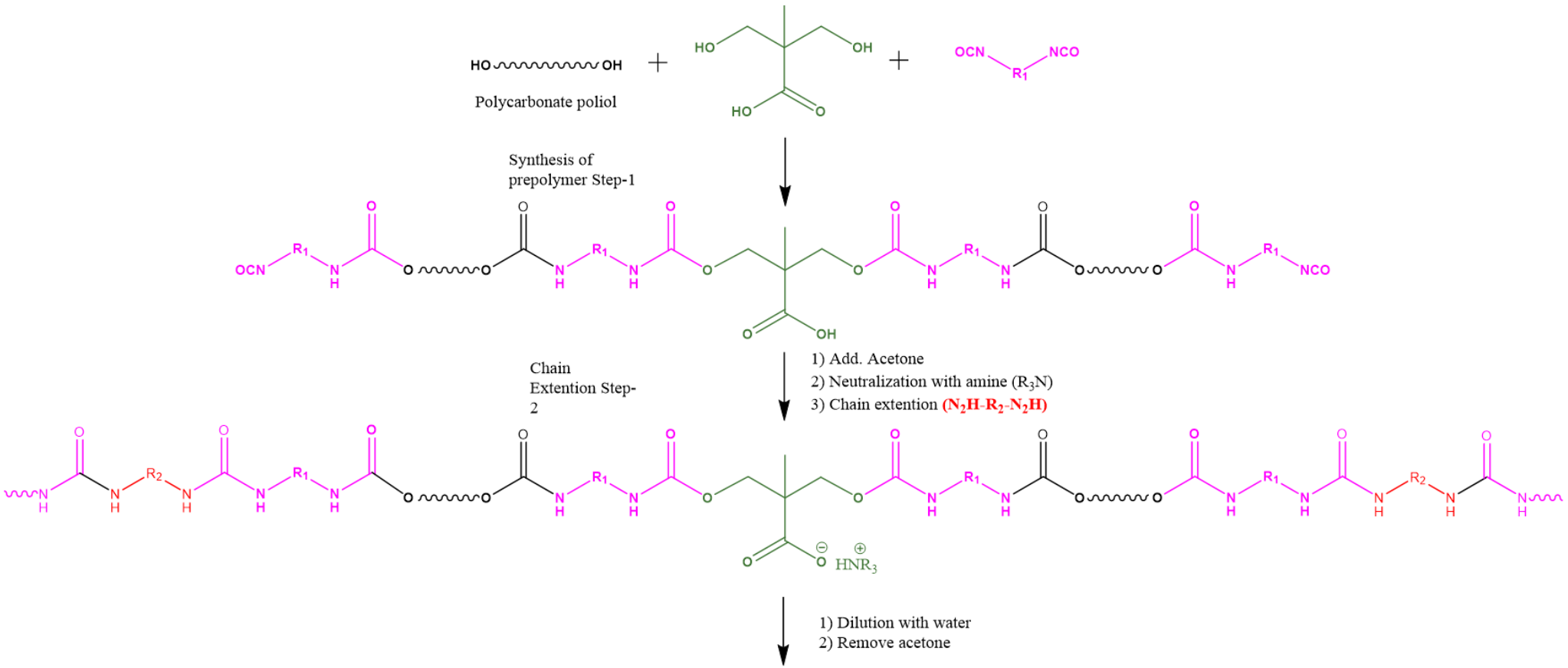
polyether<polyester<polycarbonate

-CH_2- CH_2-O-<R-C=O<R-O-C=O-O-R

aliphatic<cycloaliphatic<aromatic



chemistry behind it



synthesis of aliphatic polycarbonate-based waterborne polyurethane

formulation

Aliphatic polycarbonate-based waterborne polyurethane dispersion

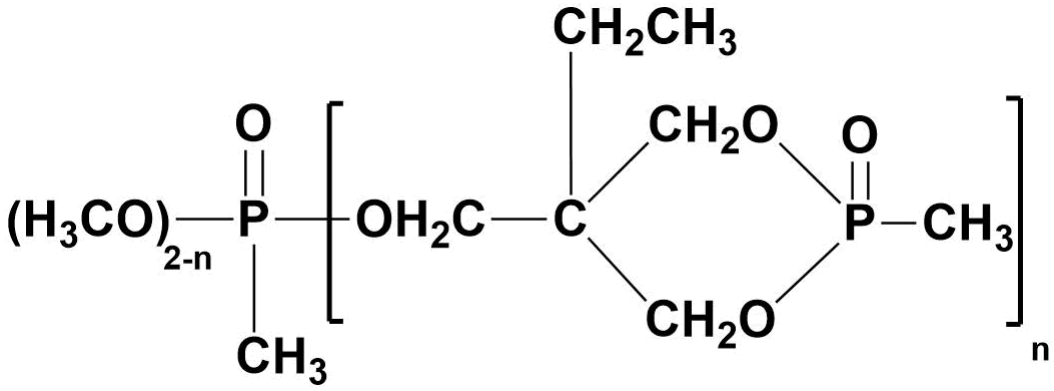
pH: 7.5

Particle Size Dist.: 175 nm

Non-Aqueous Content: 35%, 160 °C

Coating Formulation:

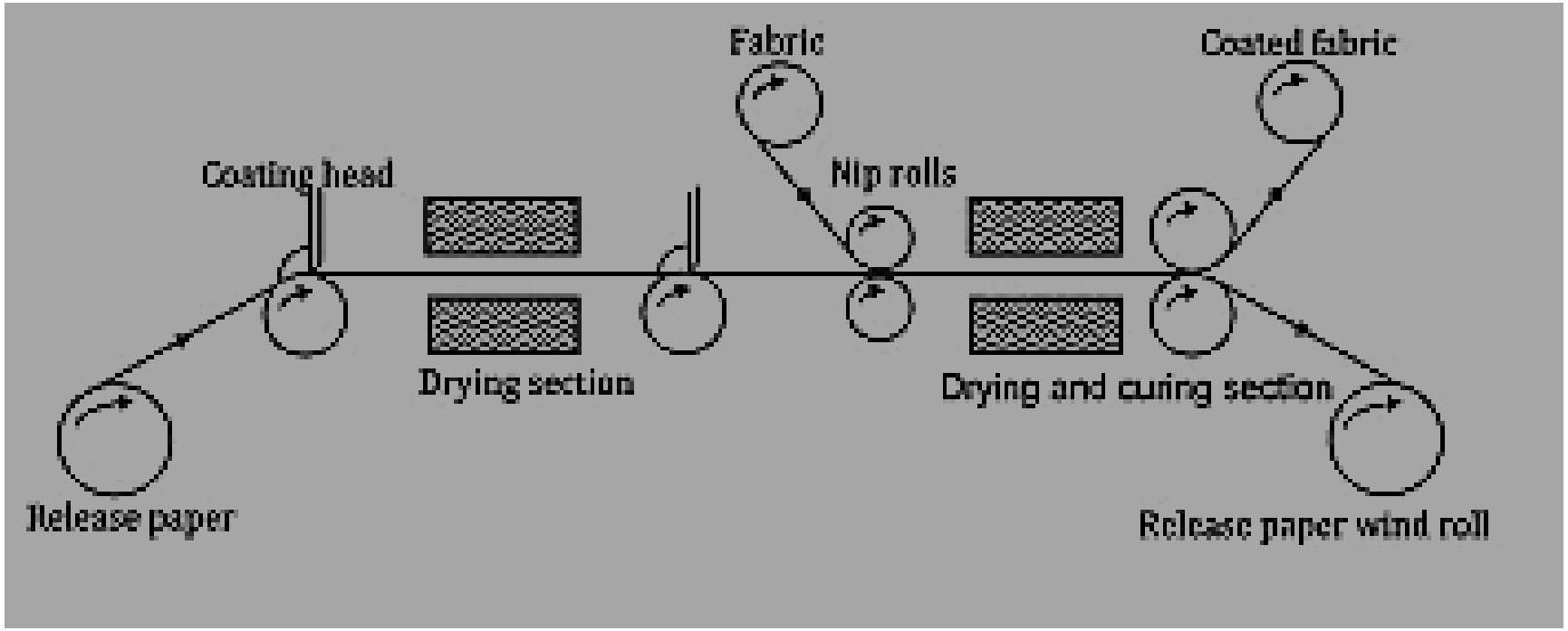
1. **WPUD+cyclophosphonate**
2. **Acrylic-based thickener**
3. **Deaerating agent**
4. **Blocked isocyanate**



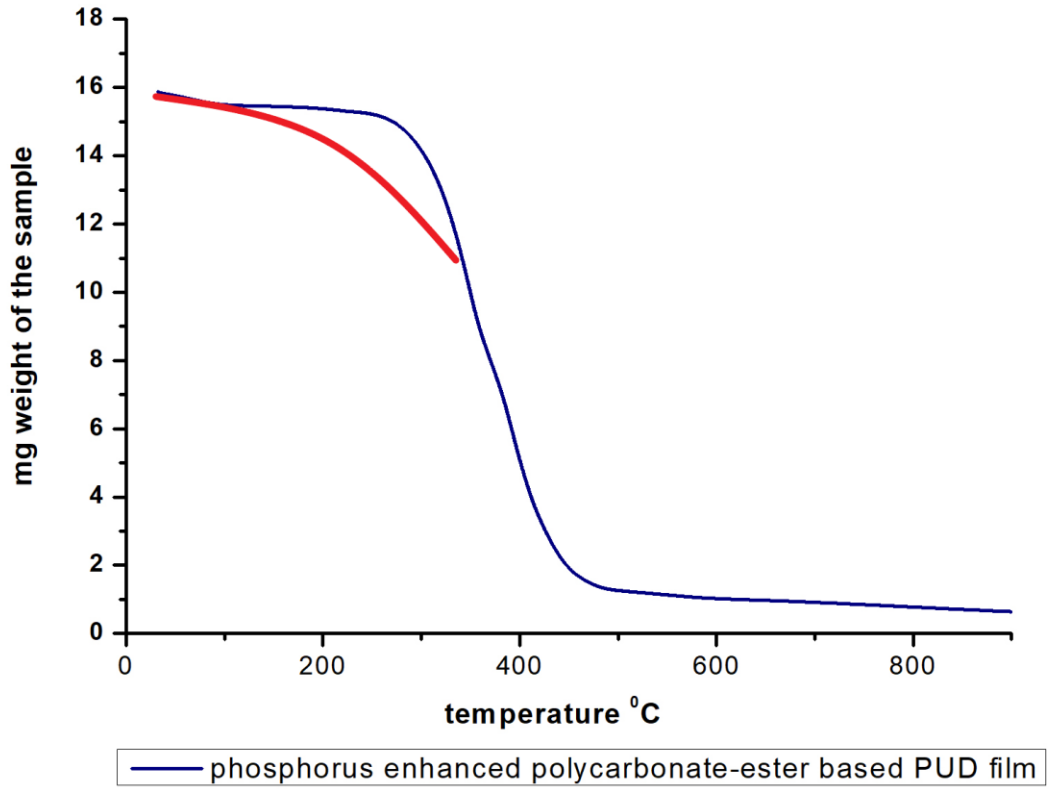
commercially available

application

1. Dipping in the solution of FR for the covalent attachment
2. Transfer coating formulation from paper onto the polyester fabric



testing&result



The sample sizes were 15.0–16.0 mg, the heating rate was 10°C/min under air with 110 mL/min flow rate, and each sample was heated from 30°C to 900°C.

testing&result

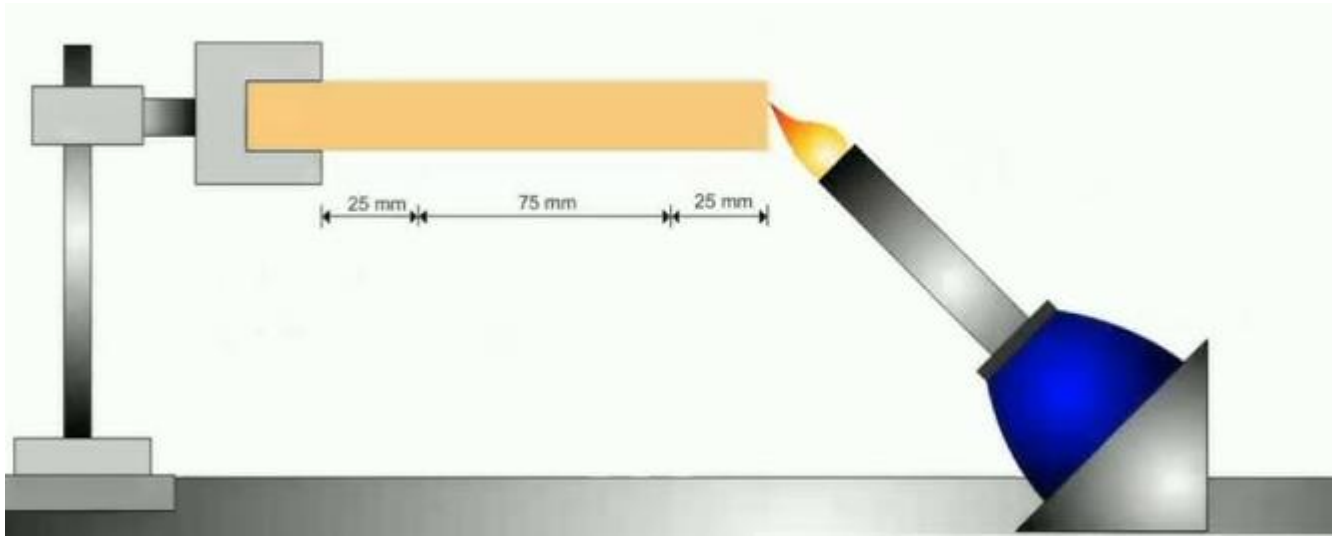
Tested according to ISO 3795:

Determination of burning behavior of interior materials

Key parameters: Time for the flame to self-extinguish.

Distance of burn propagation.

Linear burning rate in mm per minute.



No propagation

fabrics were conditioned 24h at a temperature of 23 °C ± 2 °C and a relative humidity of 50 % ± 5 %

conclusion&future directions

- Phosphorus-enhanced WPUD demonstrated effective flame resistance for this interior part
- biobased phosphorus agent
- waterborne intumescent systems
- nanocomposite enhancement

**Kung_2022, 'An Overview: Organophosphate Flame Retardants in the Atmosphere', volume22, ISSN=2071-1409 Journal of Aerosol and Air Quality Research, Taiwan Association for Aerosol Research*

Thanks to Our Team

Our cults come from belief in our
sense of wonder, *motivation* to *collaborate*,
power of our talents will carry into the future.