

New coatings made from renewable raw materials: Itaconic acid-based polymers with self-healing and switchable properties

IP Heilung

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aufgrund eines Beschlusses
des Deutschen Bundestages



Fachagentur Nachwachsende Rohstoffe e.V.



Motivation



Abrasion



Cracking



Delamination

Many ways for coating failure!



Impact damage



Stress cracking

Fiction or reality?

Past



Future?



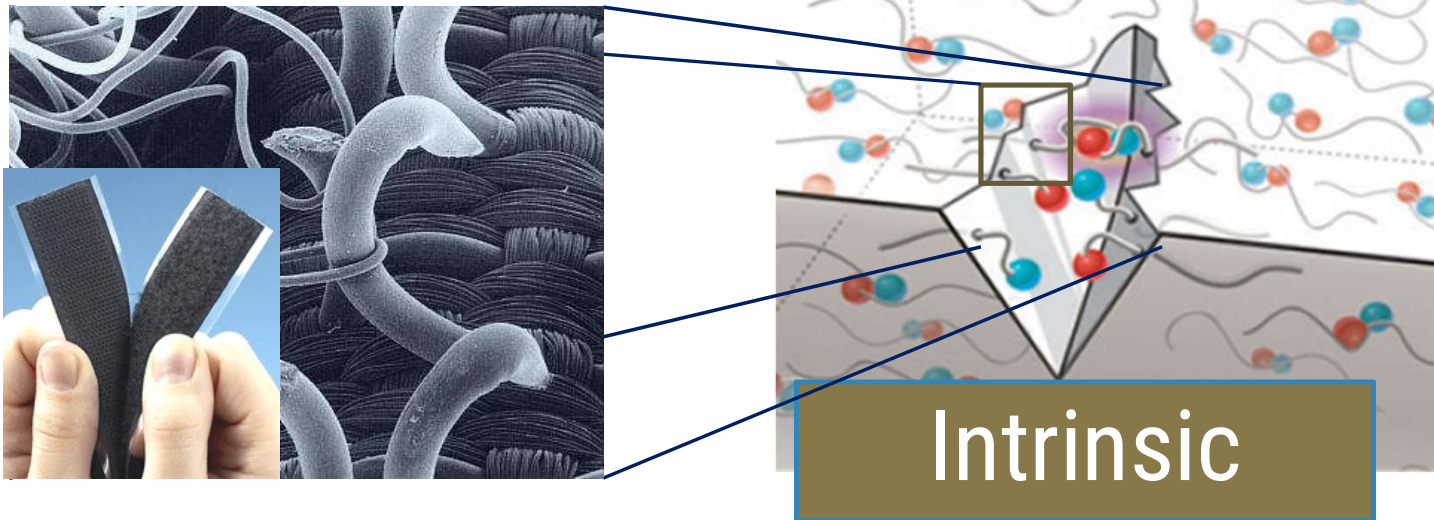
Fiction or reality?



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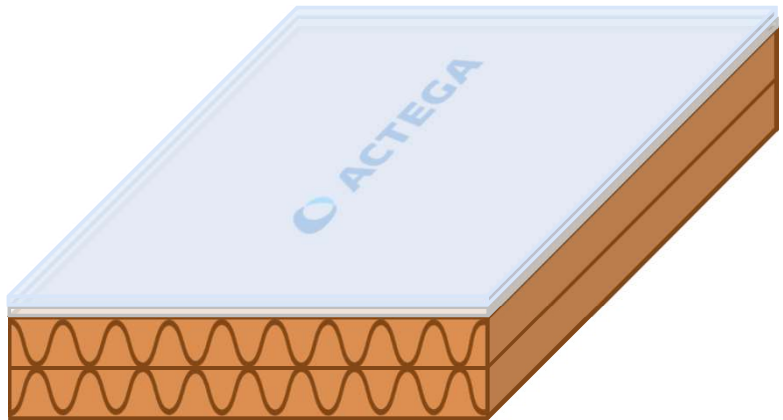


Self-healing polymers



Reversible covalent and non-covalent interactions

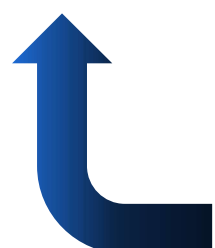
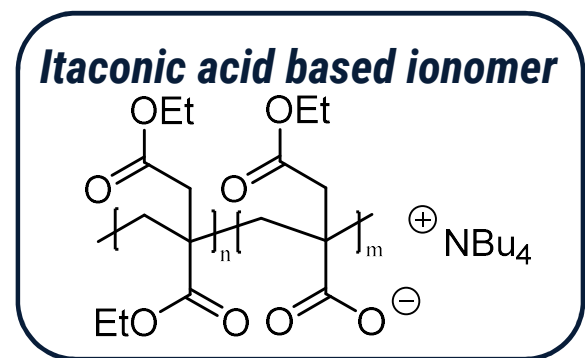
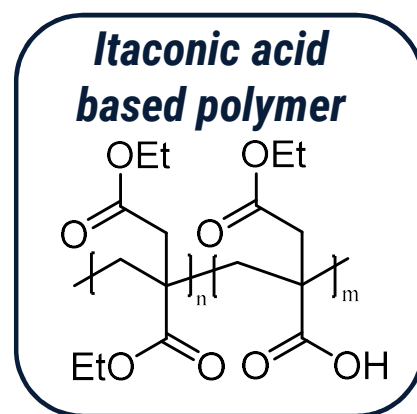
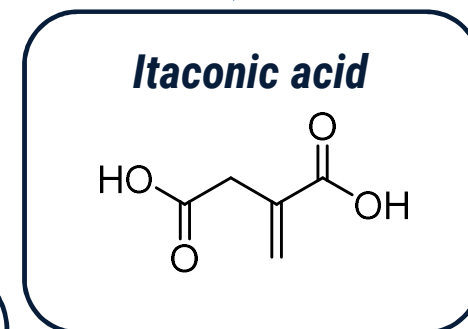
Targeted application: Packaging



Coating
Printing
Primer
Paper



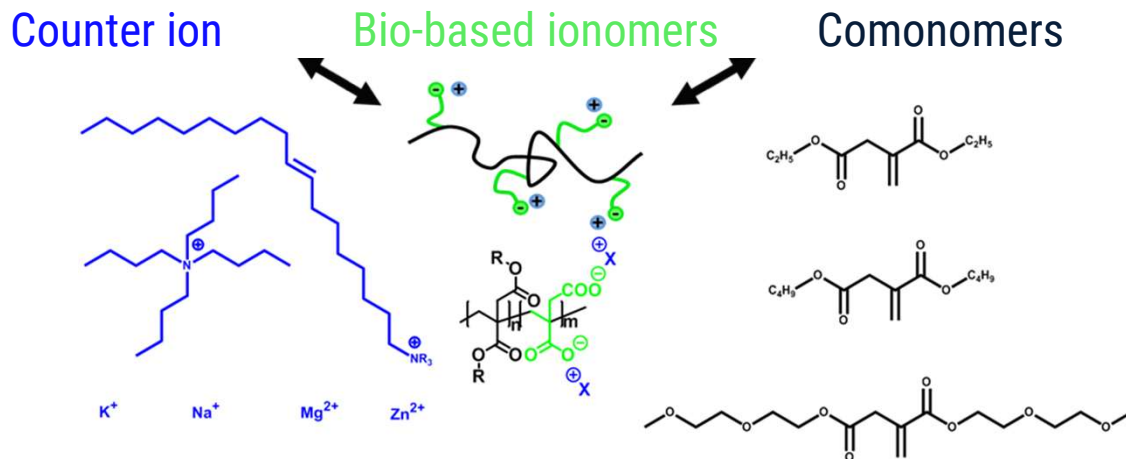
Starting point



Bio-based ionomer with self-healing abilities

J. Meurer, J. Hniopek, J. Dahlke, M. Schmitt, J. Popp, S. Zechel, M. D. Hager, *Macromol. Rapid Commun.* **2021**, 42, 2000636. <https://www.plantura.garden/gemuese/mais/mais-pflanzen>

Our aims



Understanding

Structure property-relationship

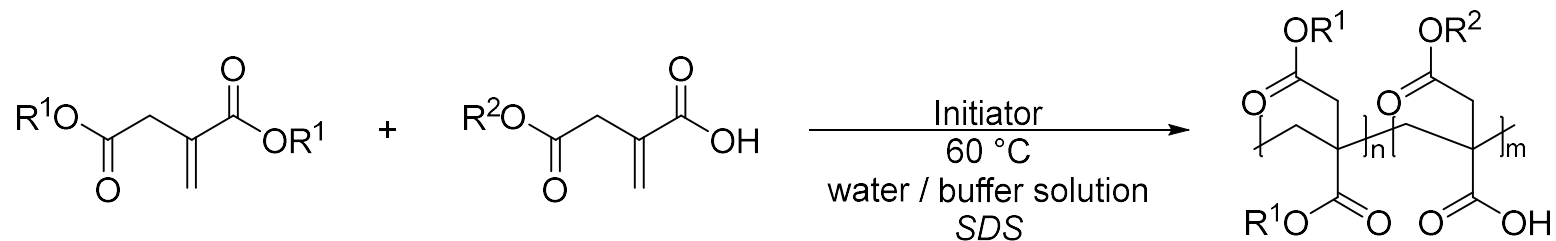
Using

Replacement of coating systems based on fossil fuels (styrene-acrylate)

Applications

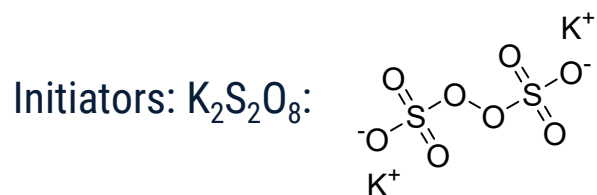
Switchable coating (blister coating)
Self-healing

Emulsion polymerization

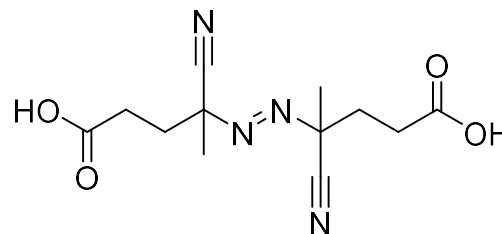


R¹ = Ethyl (DEI)
= Butyl (DBI)

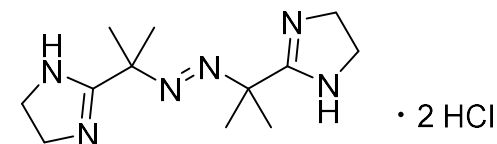
R² = Butyl (MBI)
= Dodecyl (MDI)



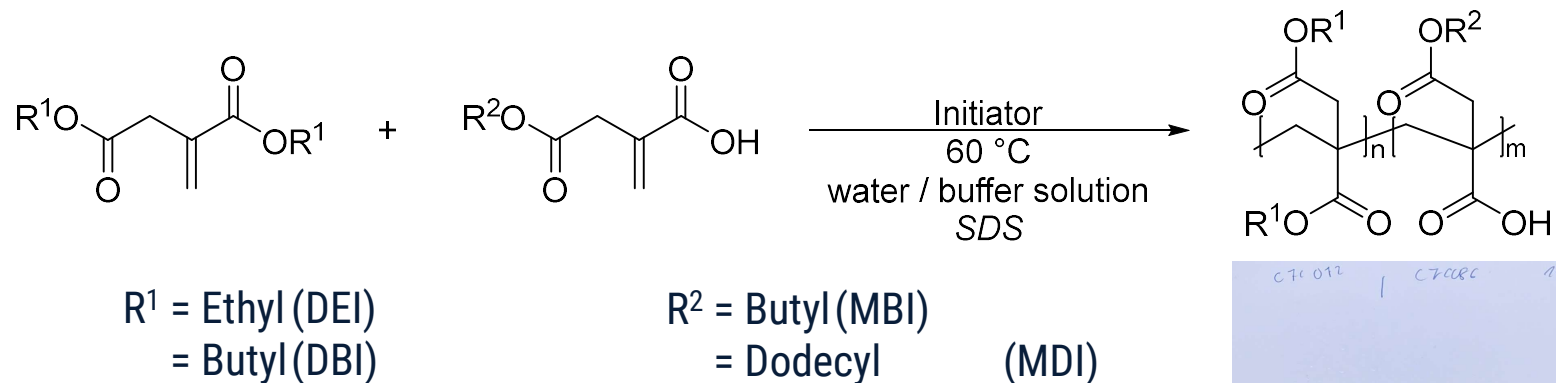
ACPA: 4,4'-Azobis(4-cyanopentanoic acid)



VA-044: 2,2'-Azobis[2-(2-imidazolin-2-yl)propane] dihydrochloride

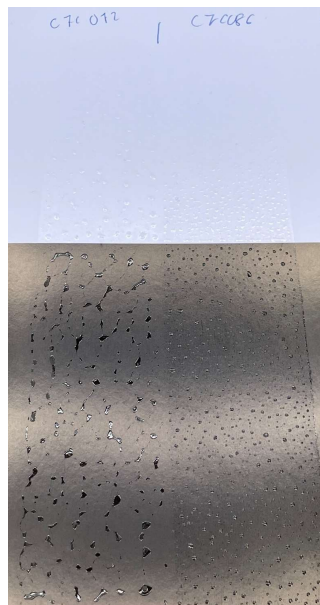


Emulsion polymerization



Successful synthesis

Yield could be improved from below 10%
to almost complete monomer conversion



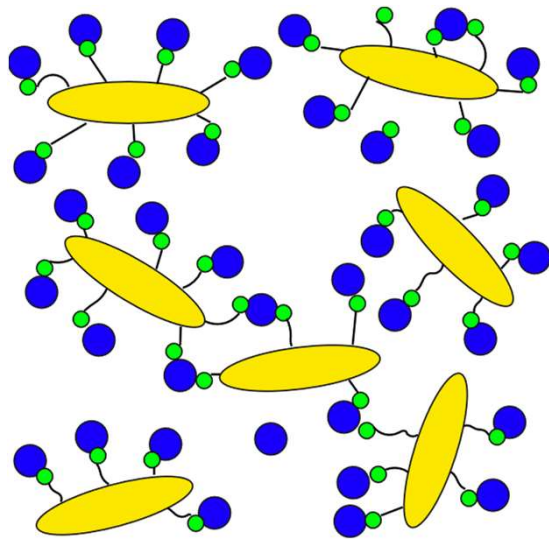
But poor film formation



Mechanism of rheology modifiers

HASE

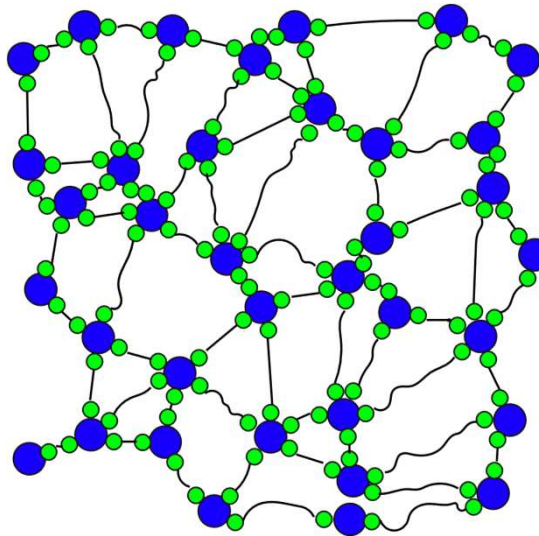
Hydrophobically modified alkali swellable acrylate



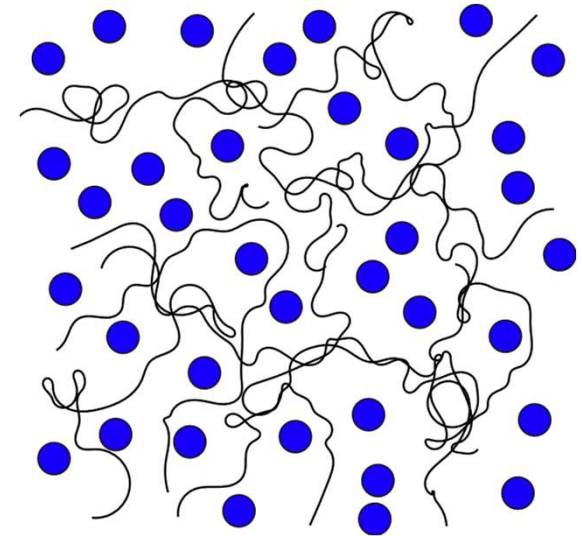
HEUR

Hydrophobically modified ethoxylated polyurethane

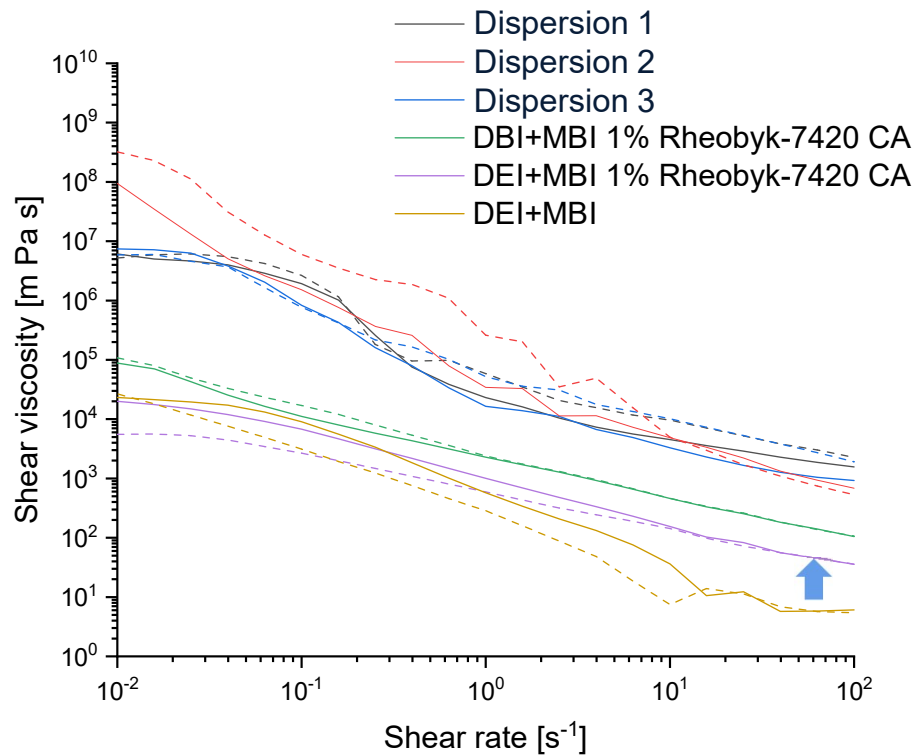
Polyamide modified urea



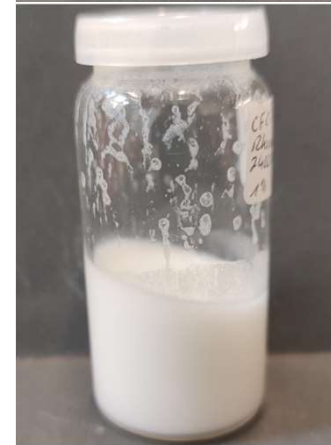
Swelling and thickening without interaction



Rheology measurements of emulsions with 1% Rheobyk-7420 CA

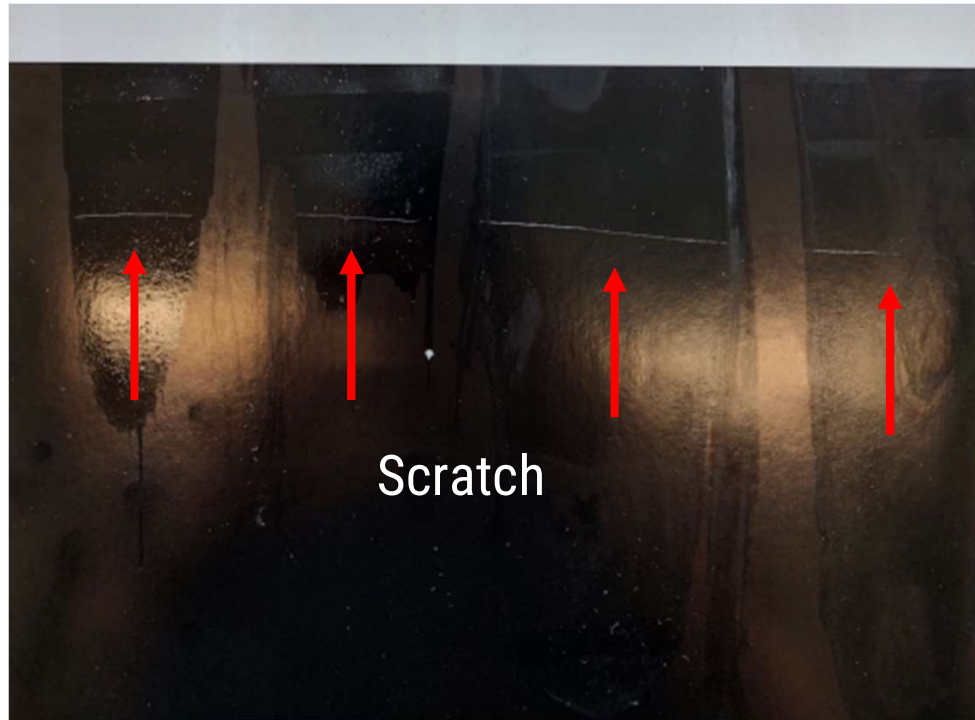


DBI+MBI
Rheobyk-7420 CA (1%)



DEI+MBI
Rheobyk-7420 CA (1%)

Coatings of emulsions with 1% Rheobyk-7420 CA: Self-healing in more detail



P1
5 μm 10 μm P2
5 μm 10 μm



P1
5 μm 10 μm P2
5 μm 10 μm

Application & next steps

- **Application tests:**
 - Self-healing properties
 - Printing on coatings
 - Blister coatings
 - Barrier coatings
 - Recycling of coated paper



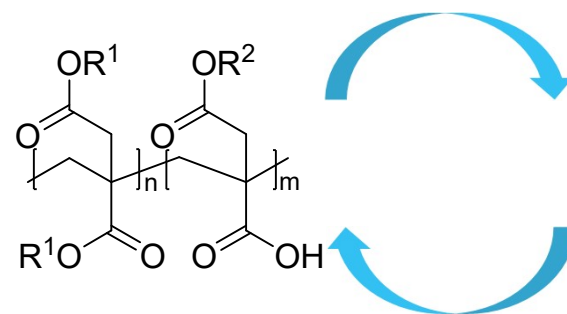
Upscaling 



Industrial reference



Self-healing coating



Application tests

Conclusion

- Polyitaconates can be used for self-healing coatings
- Polyitaconates can be prepared successfully *via* an emulsion polymerization
- Rheology additives were successfully utilized to increase the viscosity of the polymer dispersions
- Promising rheology additive identified - Rheobyk-7420 CA
- Dispersions with rheology additive resulted in good films
- Films obtained *via* the dispersions still show self-healing ability (comparable examples are scarce in literature)
- Conversion of the polymerization is higher than 99%

Acknowledgement & support



Charlotte Fischer von Mollard

Dr. Stefan Zechel

 **ALTANA**

 **ACTEGA**

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des Deutschen Bundestages



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