Thermally activated catalyst in dynamic covalent network applied in debonding on-demand process for adhesives disassembly

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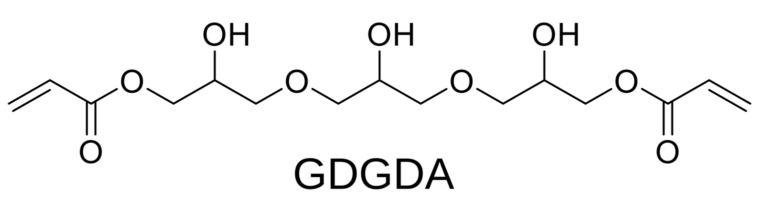
INTRODUCTION AND MOTIVATION

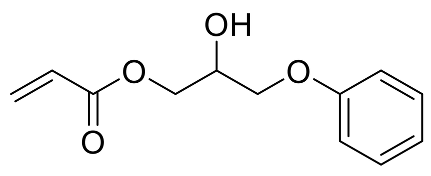
- **Structural adhesives typically require aggressive treatments to separate the substrates at the end of their life. These treatments can damage components or compromise the recycling of bonded parts.**
- **An adhesive that can be de-bonded on-demand in a controlled and selective way could make the de-bonding process easier.**
- **Vitrimers are emerging as a new class of polymers with a three-dimensional covalent network. In response to a specific external trigger, they are able to undergo dynamic bond exchange reactions. The related changes in viscoelastic properties can be exploited for cohesive debonding of adhesives.**
- **Several latent catalysts have been studied to enable temporal control of dynamic bond exchange reactions. Activated by a specific external trigger, they can catalyze the reactions.**
- **The selected trigger to activate the latent catalysts is temperature (> 180° C).**

SYSTEM COMPOSITION

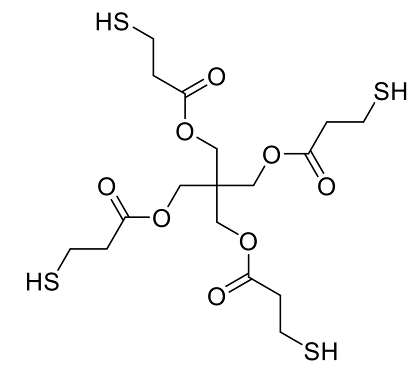
MONOMERS:



GDGDA

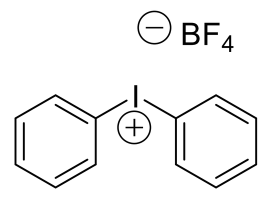


HPPA

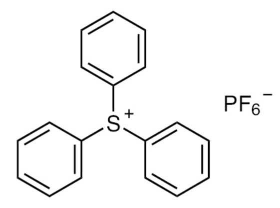


PETMP

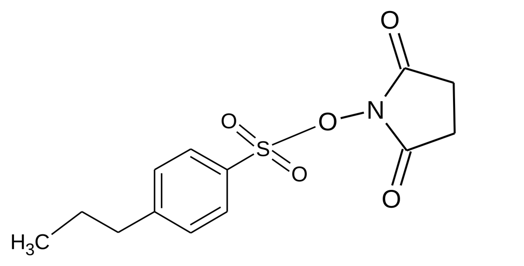
LATENT ACID CATALYSTS:



DPI BF_4

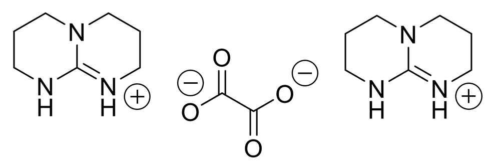


TPS PF_6



NHS 4PBSC

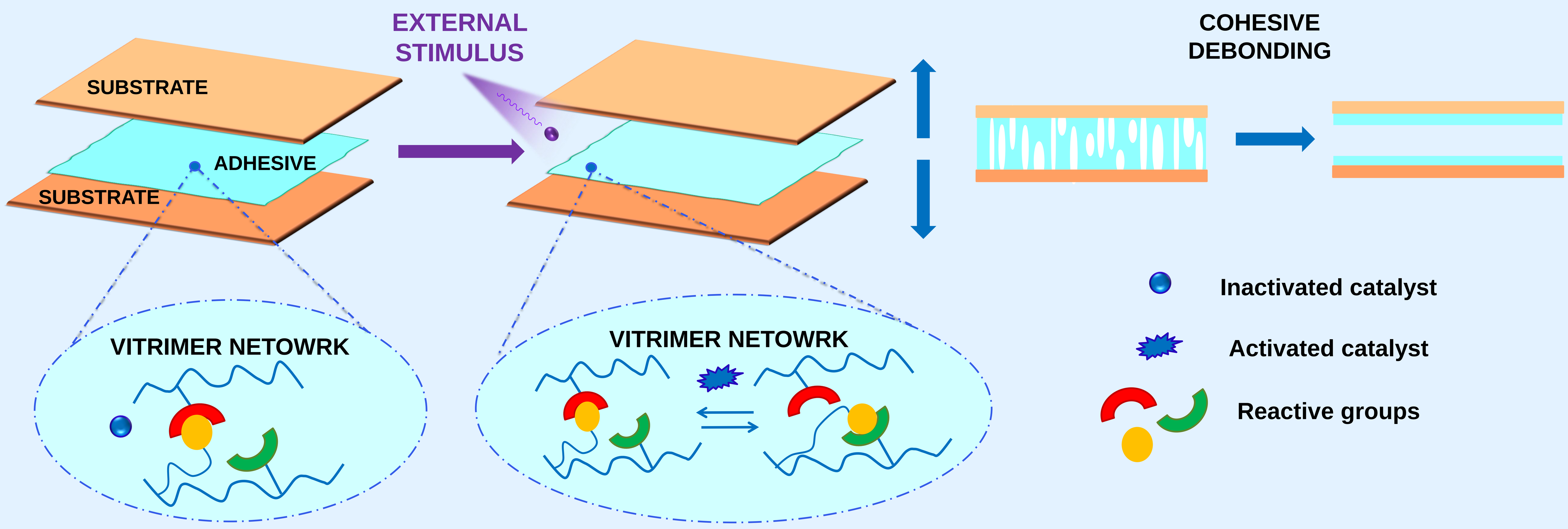
LATENT BASE CATALYSTS:



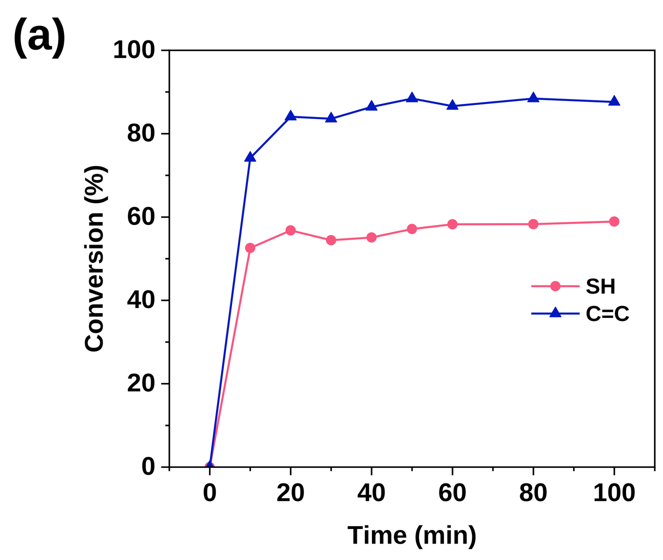
$[TBD]_2[OX]$

THERMAL RADICAL INITATOR:

BPO



RESULTS



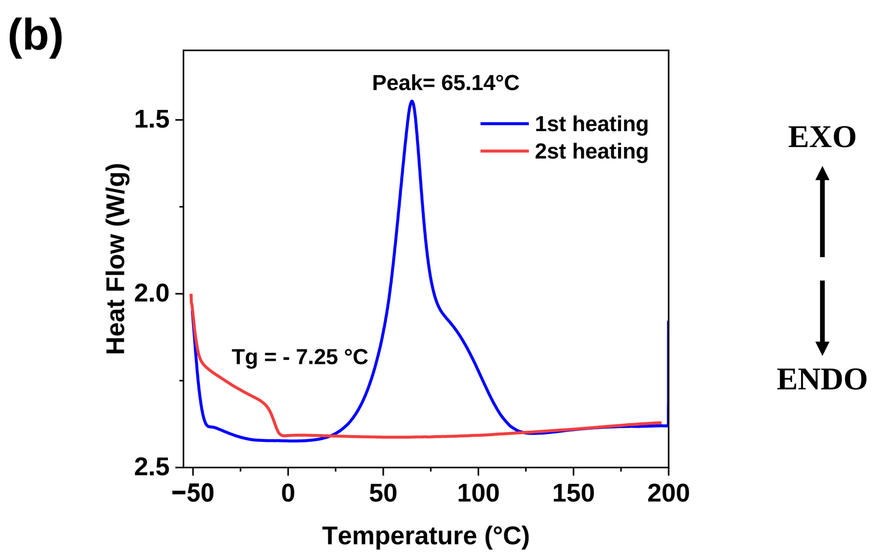
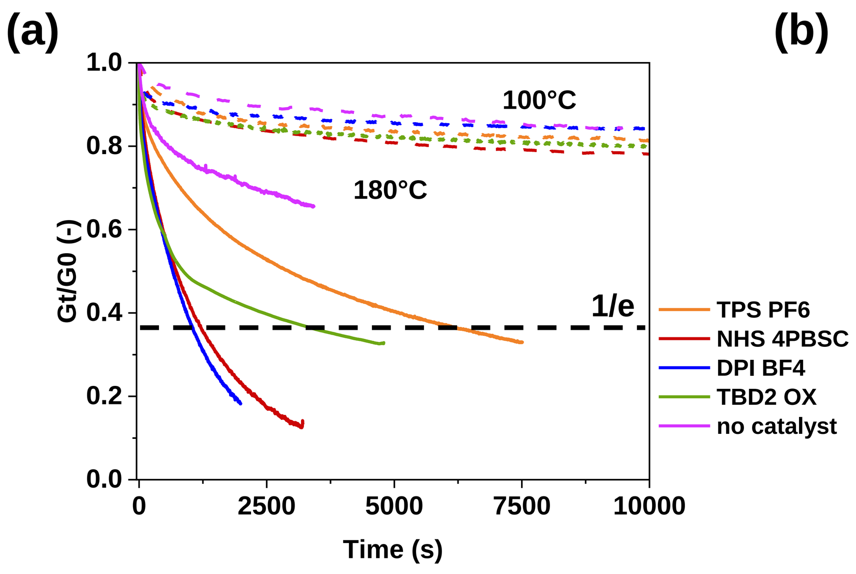


Figure 1: Analysis of curing process **(a)** Conversion of functional group over time extrapolated from the peak area of SH (2570 cm^{-1}) and C=C (1640 cm^{-1}) during curing process performed at 80° C **(b)** Dynamic DSC study of curing process.



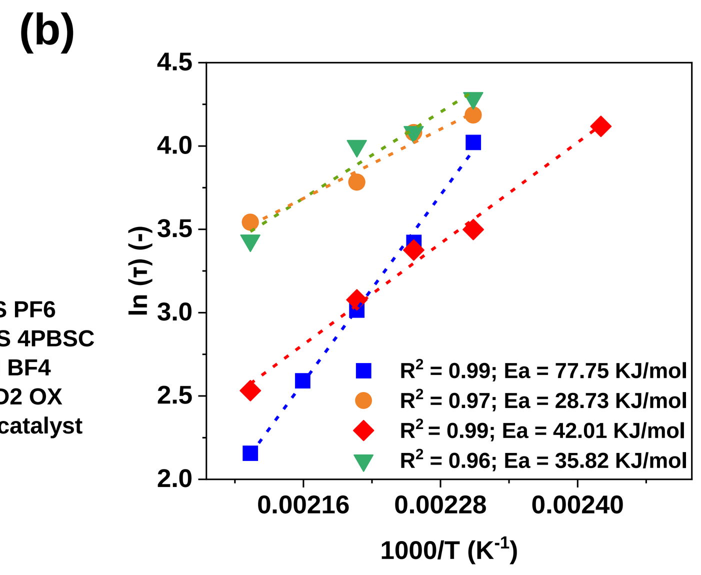
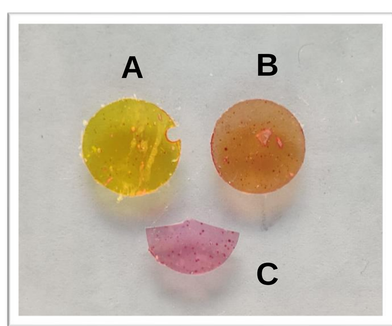


Figure 2: Study of dynamic network **(a)** Stress relaxation curves of thiol-acrylate adhesives with different catalysts performed at 180° C and 100° C **(b)** Arrhenius plot of thiol-acrylate adhesives showing the linear trend of dynamic network following an associative bond exchange mechanism and the related activation energy value for the process (Ea).



pH indicator	pH range				
Thymol blue	1.2	2.8	2.9 - 7	8.2	9.6

Figure 3: Picture showing the thiol-acrylate adhesive cured with thymol blue. The colour change indicates a change in pH due to the thermal activation of the catalyst. **A:** inactivated sample; **B:** activated sample 100° C 20 min; **C:** activated sample 180° C 5 min.

CONCLUSION AND OUTLOOK

- **A thiol-acrylate adhesive that can rearrange its network through an associative mechanism involving a dynamic bond exchange reactions has been developed.**
- **Latent catalysts that are activated by temperature have been identified.**
- **The catalysts appear to be effective in the following order: DPI BF_4 = NHS 4PBSC > $[TBD]_2[OX]$ > TPS PF_6. This is due to the stability and reactivity of the catalyst within the system.**
- **The corresponding changes in viscoelastic properties due to the dynamic network will be exploited for cohesive de-bonding process.**
- **The next step is to characterize the adhesive strength using the single lap shear test.**
- **Thermal expandable fillers will be introduced to facilitate the adhesive failure process.**

References
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