# *DoDyNet Kickoff meeting*

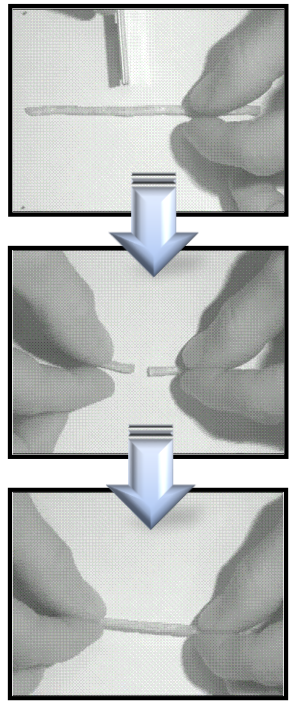
## *Soft Matter and Chemistry Lab*

**Dynamic Covalent Chemistry and Macromolecular Engineering**

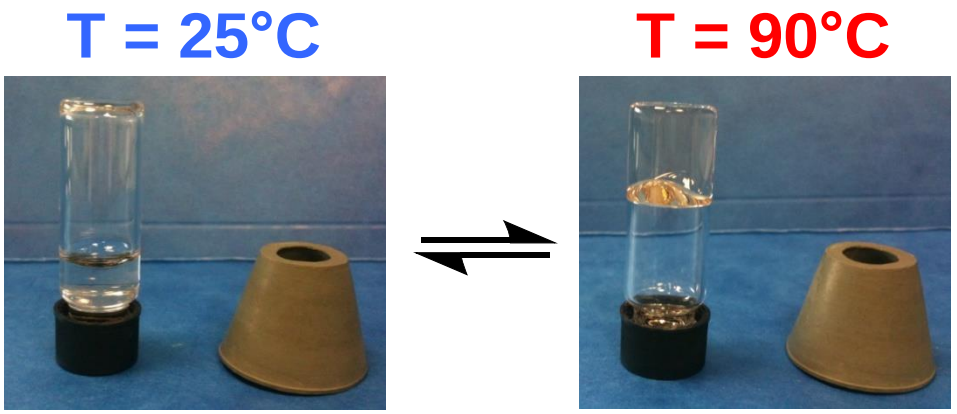
***Renaud Nicolaÿ***



# *Soft Matter and Chemistry Lab*



- **Supramolecular Polymers**
- **Vitrimers**
- **Soft Matter Rheology**
- **Composites/Hybrid Materials**




Cordier, P.; Tournilhac, F.; Soulié-Ziakovic, C.; Leibler, L., *Nature* **2008,** *451*, 977

Montarnal, D.; Capelot, M.; Tournilhac, F.; Leibler, L. *Science* **2011**, *334*, 965

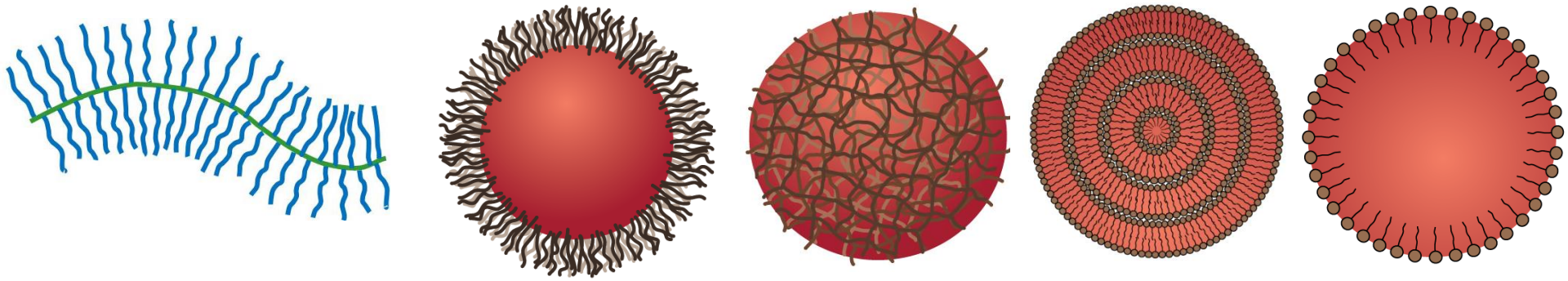
WO2015110642, WO2015110643, WO2016EP50400, FR1661400, FR1661403

# Soft Matter and Chemistry Lab

## High Solid Dispersions

Polymer-colloids

Soft colloids



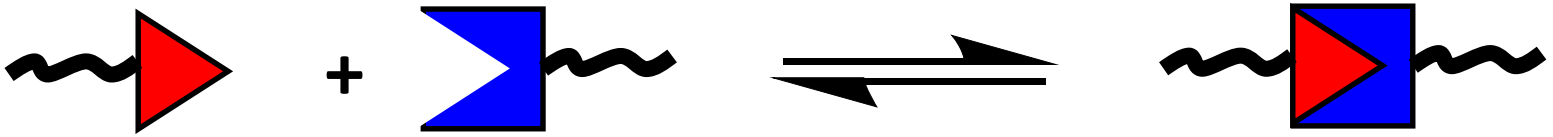
Tailoring macroscopic behavior from particle scale properties:

- Yield stress fluids
- Shear-thickening and gelling fluids
- Encapsulation of hydrophobic substances
- Functional polymers for water-soluble formulations

***A micromechanical model to predict the flow of soft particle glasses,*** **Jyoti R. Seth, Lavanya Mohan, Clémentine Locatelli-Champagne, Michel Cloitre, Roger T. Bonnecaze, Nature Materials 10, 838 (2011)**

# *Reversible and Dynamic Covalent Chemistry*

## ✓ Reversible Covalent Chemistry



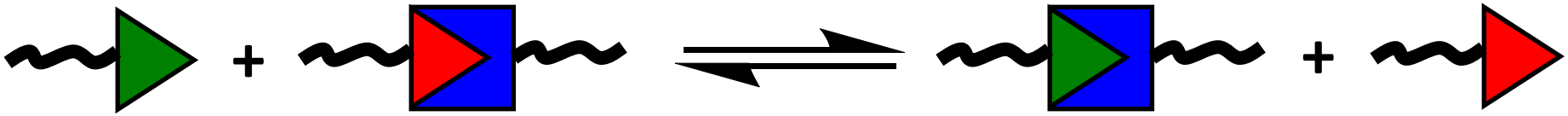
**Equilibrium constant**

$$K = \frac{k_{formation}}{k_{rupture}}$$

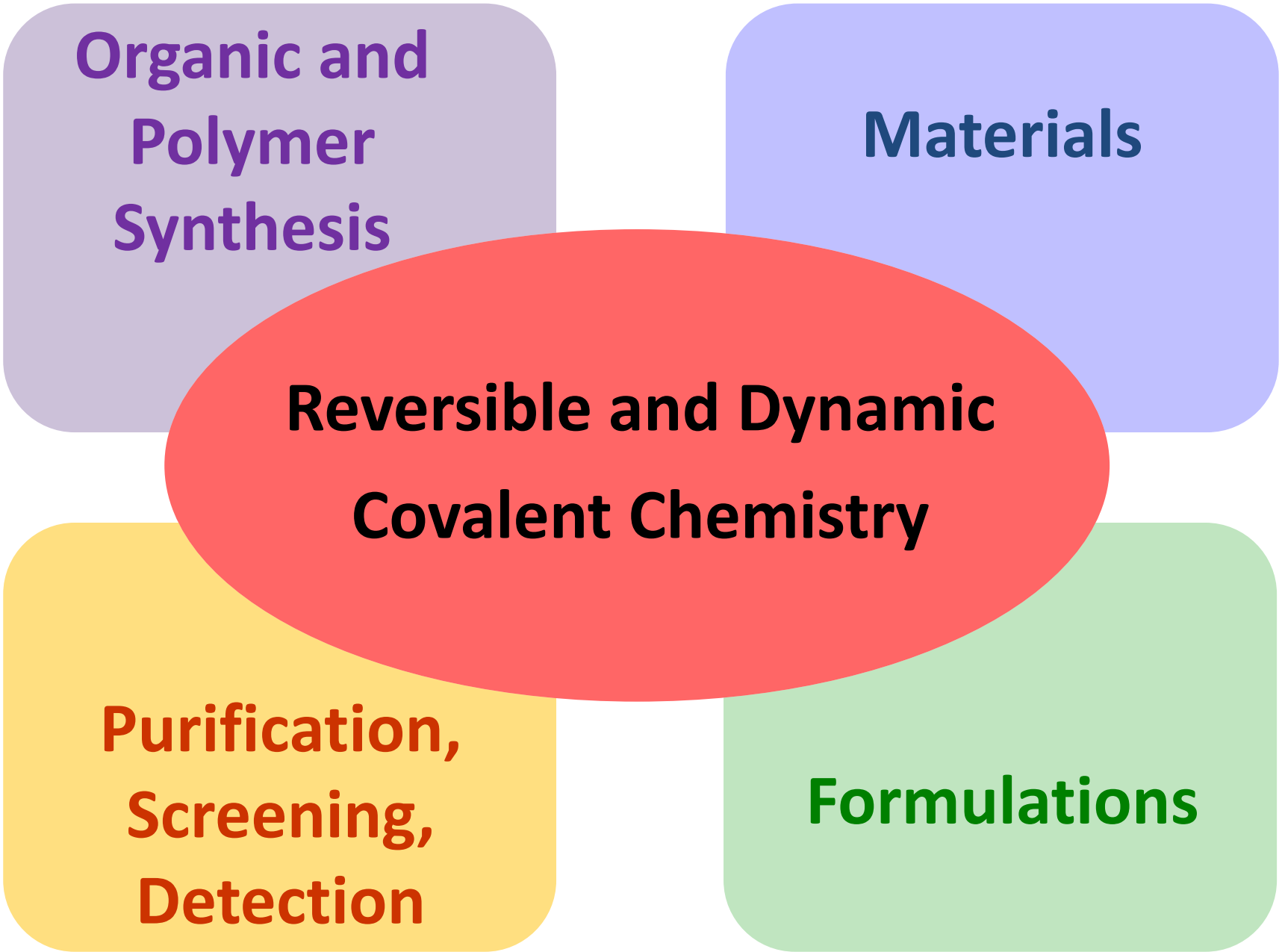
**Lifetime of the bond**

$$\tau \propto \frac{1}{k_{rupture}}$$

## ✓ Dynamic Covalent Chemistry

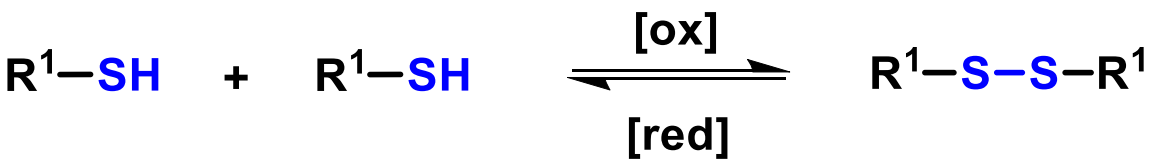


# *Chemistry and Material Science*

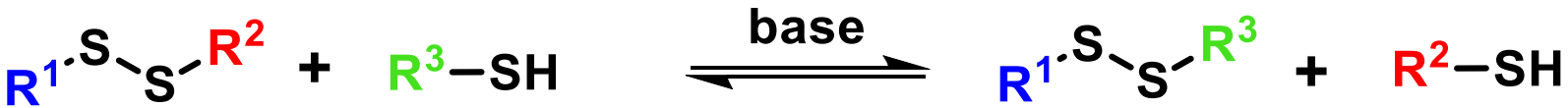


# *Thiol Chemistry*

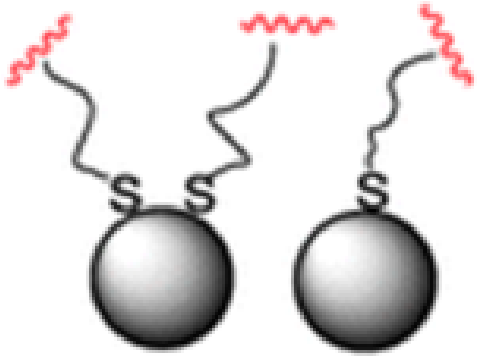
## ✓ Reversible Covalent Chemistry



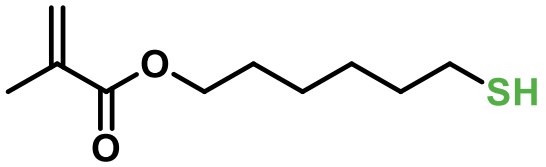

## ✓ Dynamic Covalent Chemistry

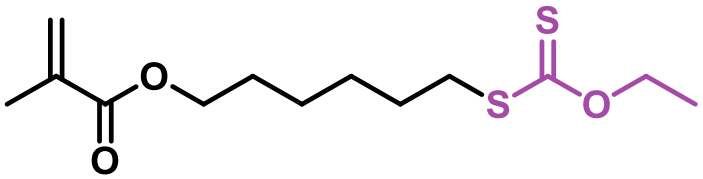


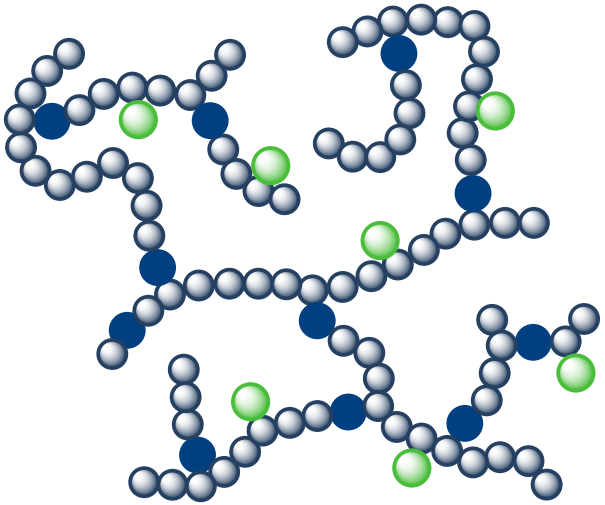

## ✓ Soft Lewis Base



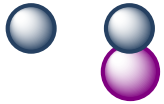
# Polymer Synthesis

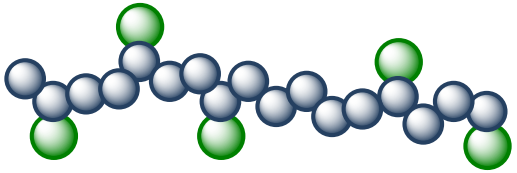


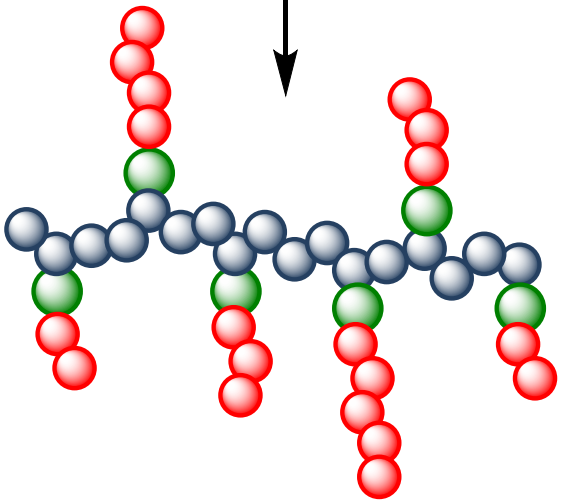



To be published



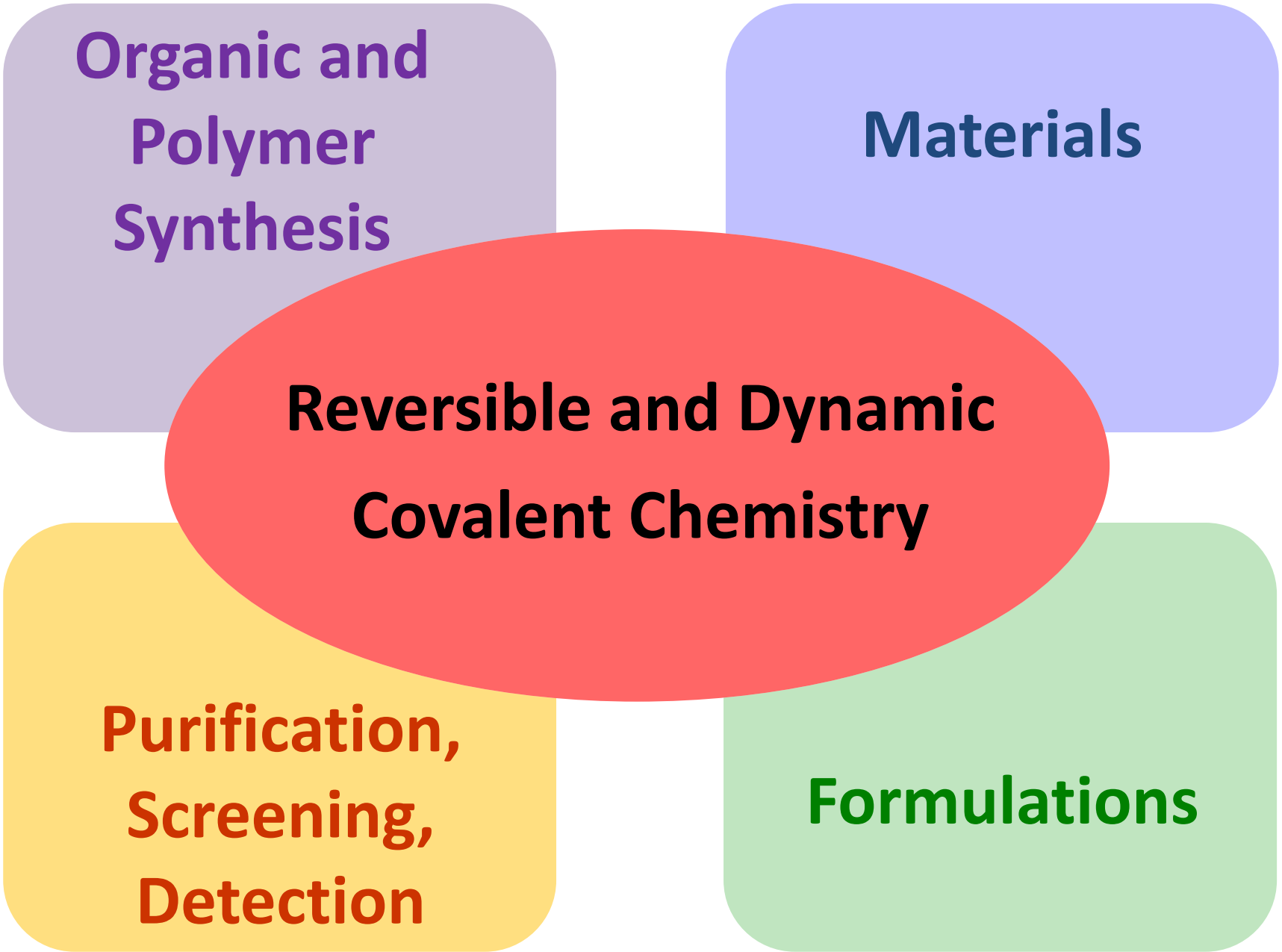


*Macromolecules* **2012**, *45*, 821
*Polym. Chem.* **2013**, *4*, 5577
*Polym. Int*. **2014**; *63*, 887
*Polym. Chem*. **2014**, 5, 4601

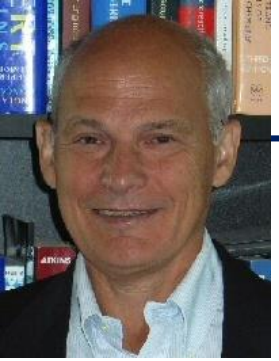


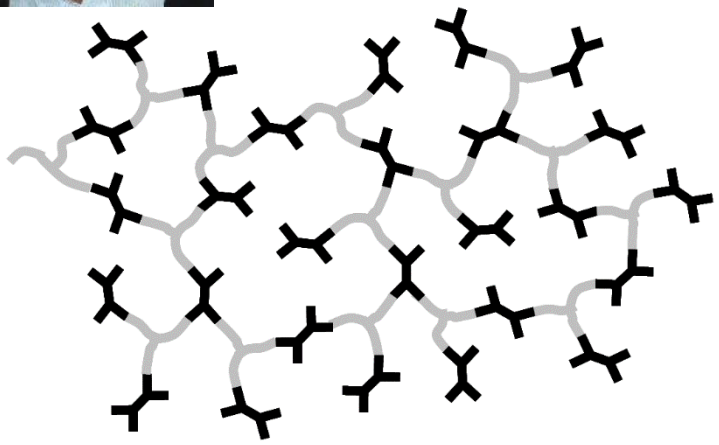
*Polym. Chem.* **2017**, *8*, 5220
Demande de brevet FR1752750

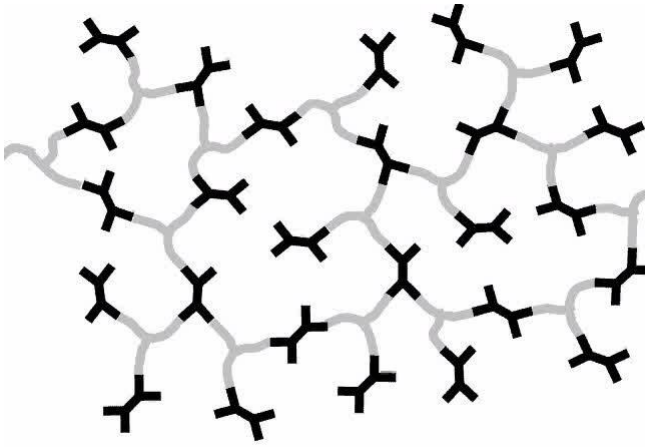
# *Chemistry and Material Science*



# Vitrimers







**Frozen Network**
**Elastic Solid**

T ↗

T ↘

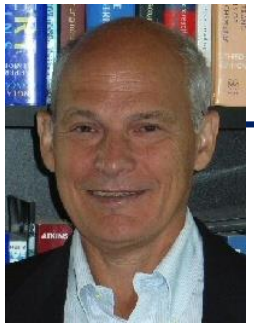
**Dynamic Network**
**Viscoelastic Liquid**

***Can flow but remain insoluble***

**Arrhenius: $\eta = \eta_0 \exp(Ea/RT)$**


Montarnal, D.; Capelot, M.; Tournilhac, F.; Leibler, L. *Science* **2011**, *334*, 965

Capelot, M.; Unterlass, M. M.; Tournilhac, F.; Leibler, L. *ACS Macro Lett.* , **2012**, *1*, 789

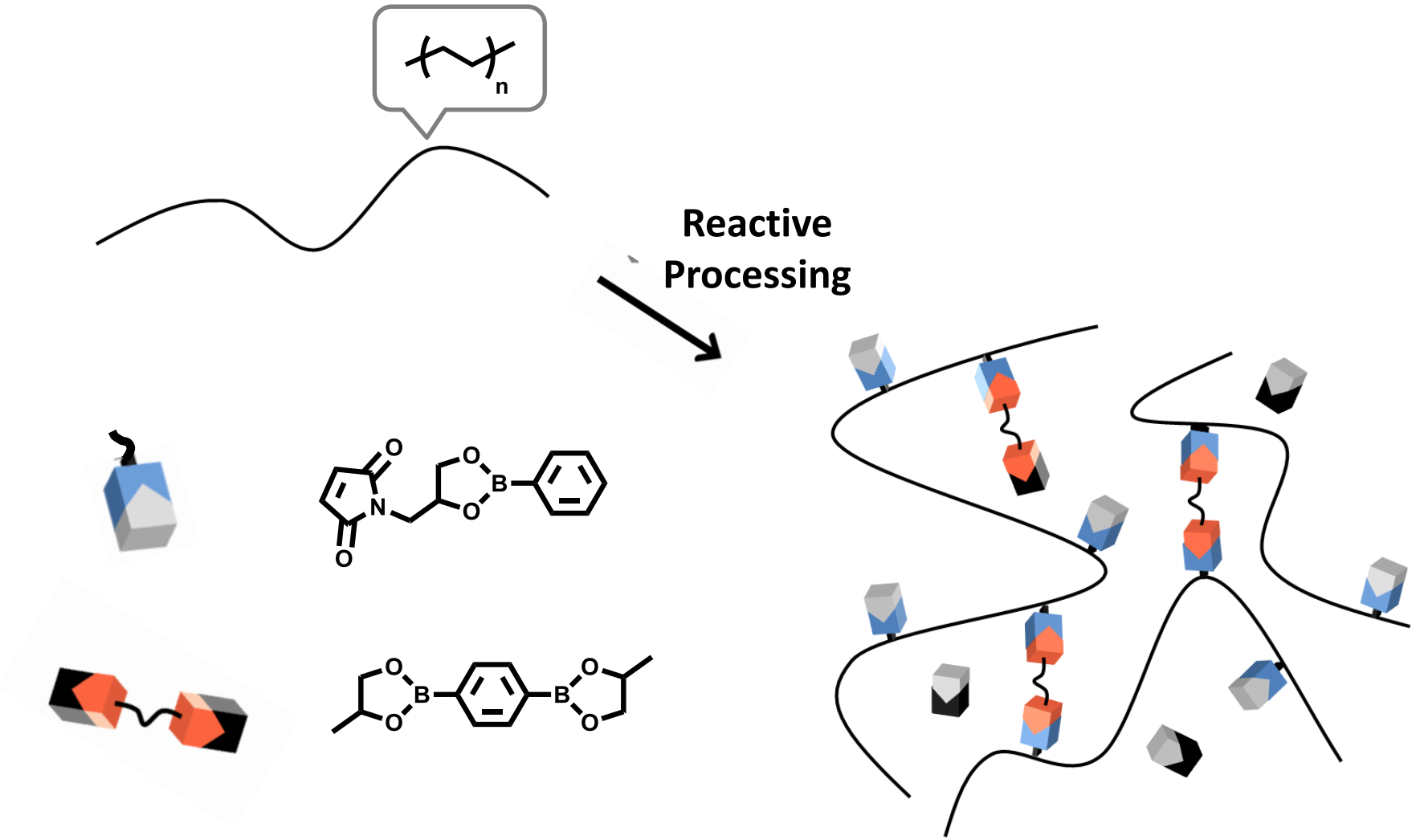


# Vitrimers from Functional Polymers




**PMMA and PS Vitrimers**

# *Vitrimers from Commercial Thermoplastics*




**"Simple" additives**

***HDPE Vitrimers***

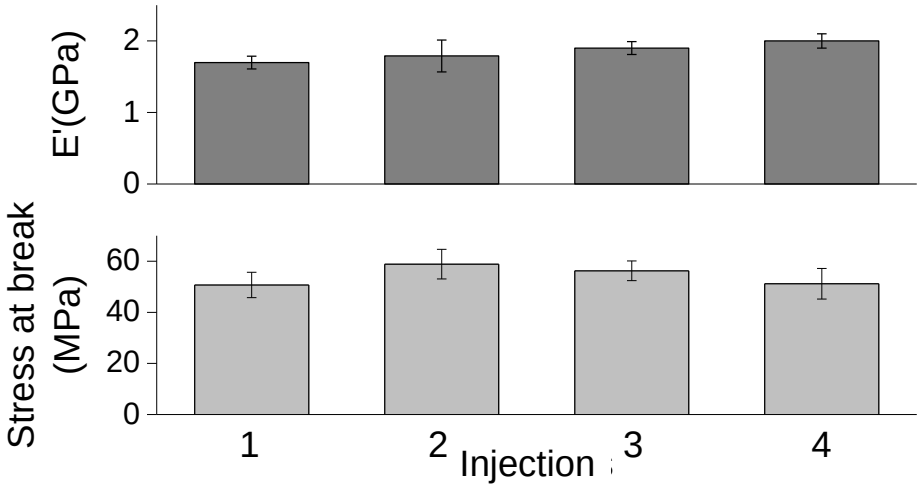
Röttger, M.; Domenech, T.; van der Weegen, R.; Breuillac, A.; Nicolaÿ, R.; Leibler, L. *Science* **2017**, *356*, 62

# Processable and Recyclable like Thermoplastics

**Injection molding**:
Melt = 200°C, mold = 180°C,
injection at 12 bar for 30 seconds

**Compression molding**:
150 °C, 10 min

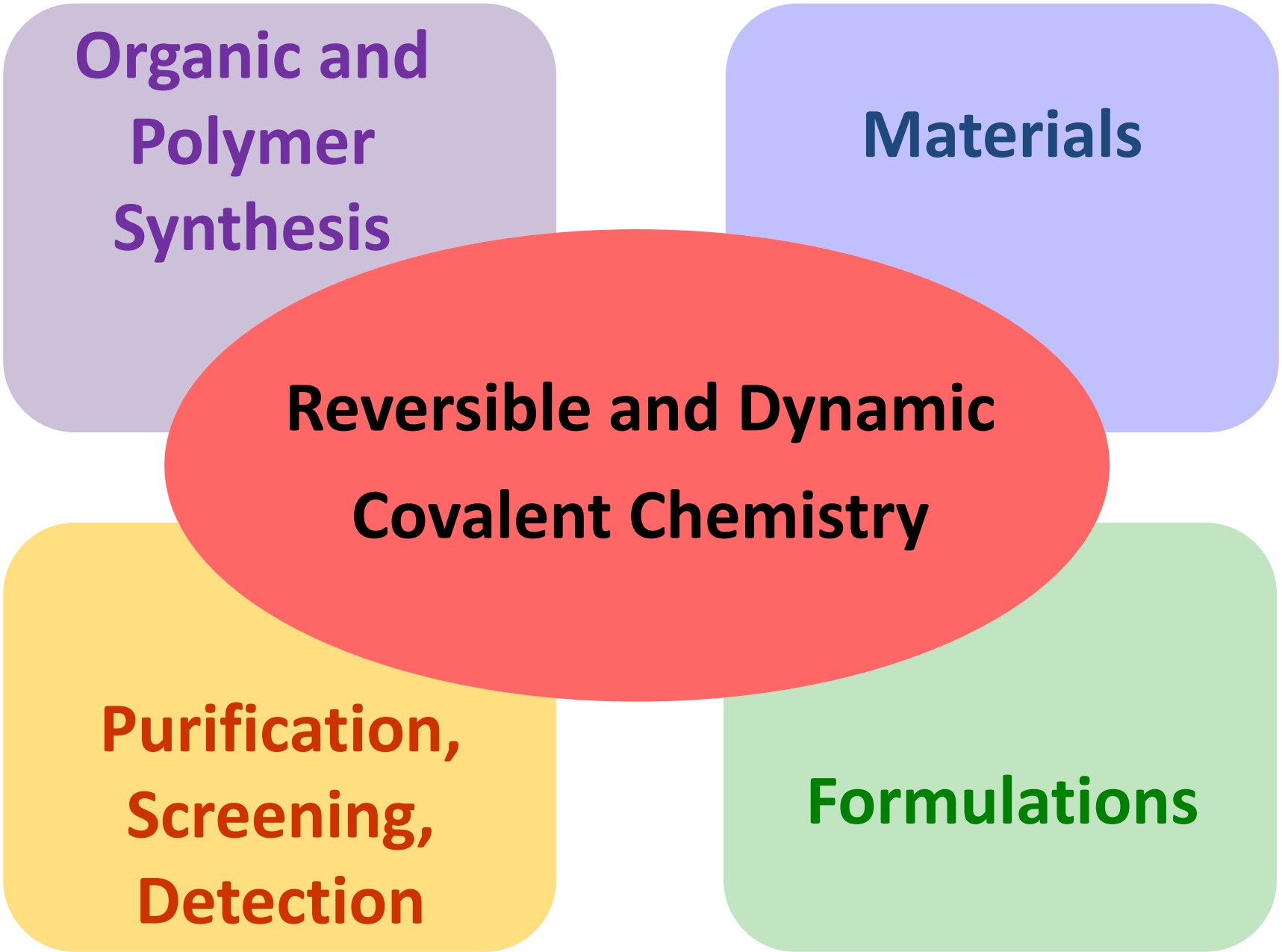

**PMMA Vitrimer**





PMMA vitrimer injection-molded and recycled 5 times

# *Chemistry and Material Science*



# *DoDyNet*

## Networks with two distinct molecular dynamics

- reversible and dynamic chemical crosslinks
- dynamic chemical crosslinks  with two different dynamics

Topology, functionality and dynamics of the crosslinks

rheological and mechanical properties of the networks

Structure and homogeneity of the networks (scattering and microscopy techniques)

Use the networks to model the rheological features of double dynamic networks