Fracture and Mechanical Properties of Elastomers filled with Soft Particles

Victoria Waltz, Jutta Rieger, Costantino Creton

Soft Matter Science and Engineering (SIMM)
Institut Parisien de Chimie Moléculaire (IPCM)

victoria.waltz@espci.fr

European Research Council
Established by the European Commission

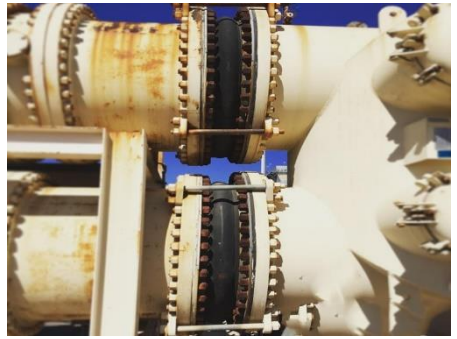
This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement n° 695351)

Context

Elastomers are
stretchable but **soft**



Industrial applications require stronger and tougher stretchable materials.

Pure elastomers suffer from a tradeoff between fracture toughness and stiffness.

composite

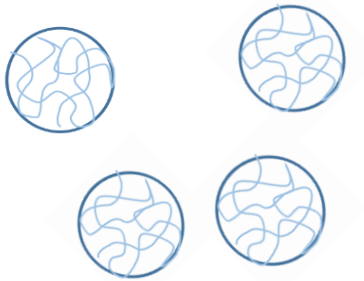
hard fillers (particles, fibers) **+** **soft matrix** (elastomers)

It works

Difficult to process
Change density
Change chemical nature
Not transparent

Soft fillers strategy

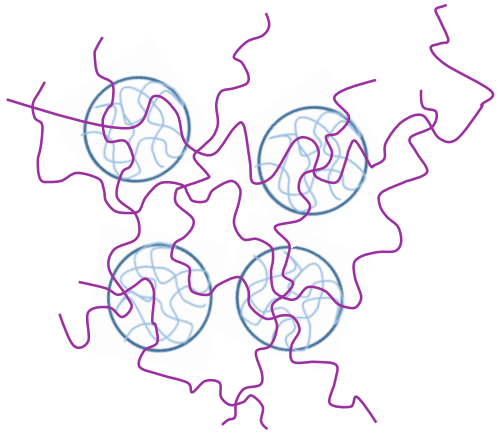
Soft elastomeric particles…



Crosslinked particles of elastomer

Particles of
Poly(Ethyl Acrylate) = PEA

…in a softer matrix

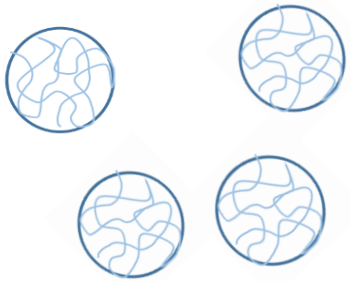


Less crosslinked elastomeric matrix

Matrix of
PEA

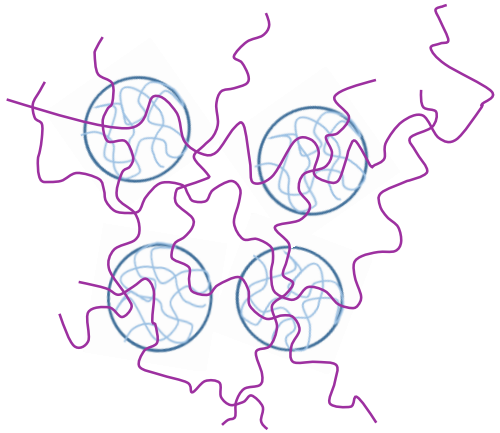
Soft fillers strategy

Soft elastomeric particles…



Crosslinked particles of elastomer

…in a softer matrix



Less crosslinked elastomeric matrix

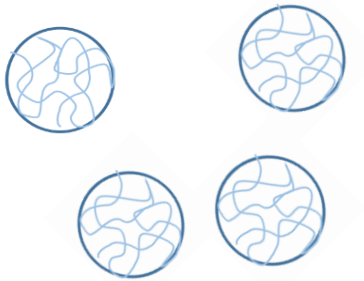
Particles of Poly(Ethyl Acrylate) = PEA

Same chemical nature between fillers and matrix
Same density

Matrix of PEA

Method

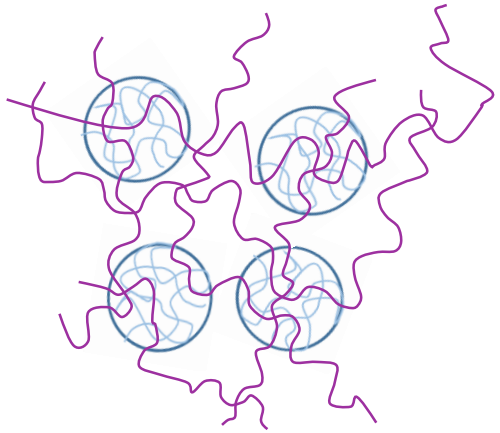
Synthesis of the soft elastomeric particles



Crosslinked particles of elastomer

Synthesis of the matrix

Final composite

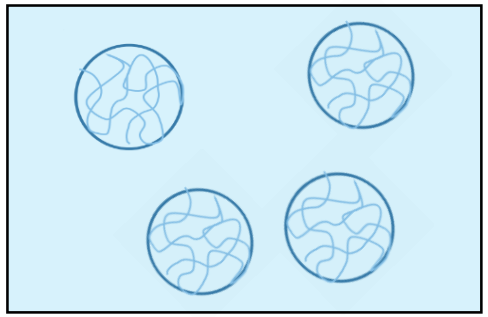


Method

Synthesis of the soft elastomeric particles

Conventional radical emulsion polymerization

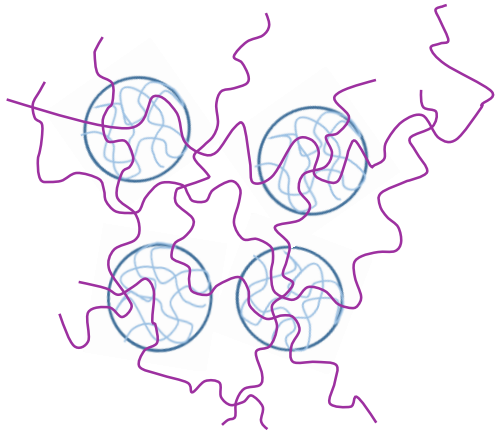
in water



Crosslinked particles of elastomer

Various crosslinker contents

Final composite

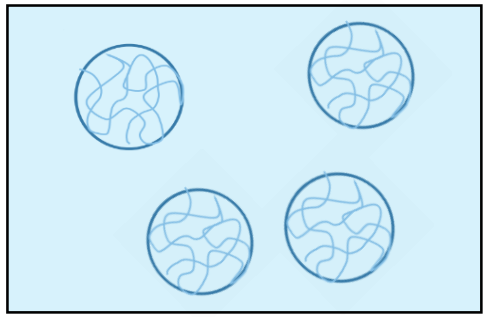


Method

Synthesis of the soft elastomeric particles

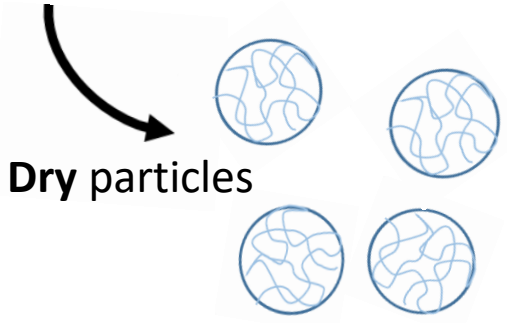
Conventional radical emulsion polymerization

in water



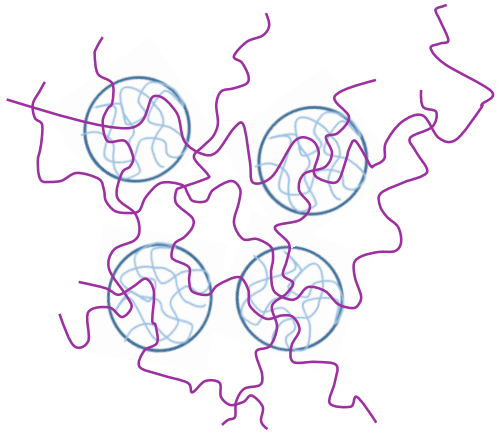
Crosslinked particles of elastomer

Various crosslinker contents



Dry particles

Final composite

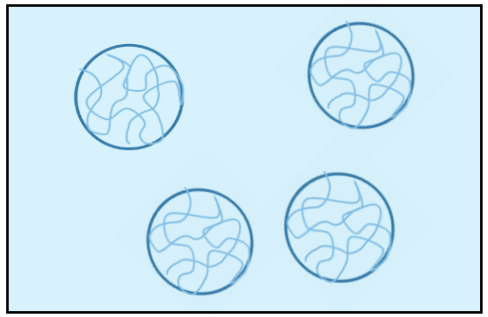


Method

Synthesis of the soft elastomeric particles

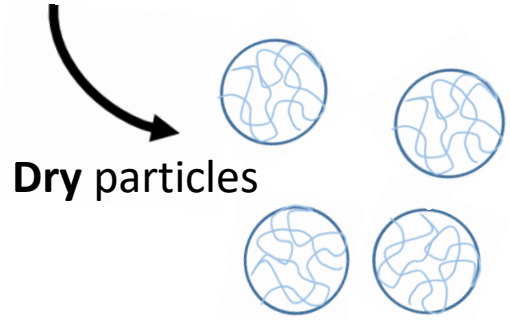
Conventional radical emulsion polymerization

in water



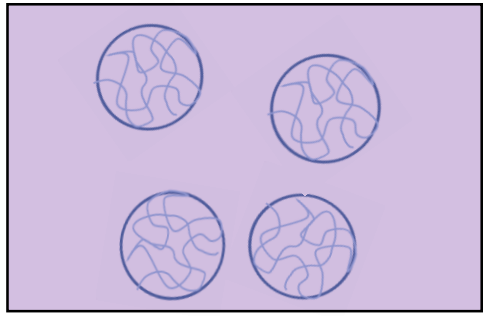
Crosslinked particles of elastomer

Various crosslinker contents



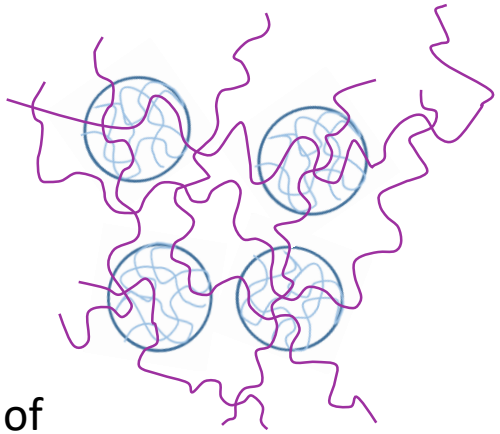
Dry particles

Dispersion and **swelling** of the dry particles **in monomer**



Various particle contents

Final composite



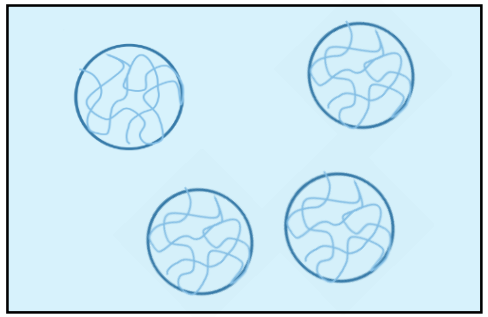
Easy dispersion of the fillers

Method

Synthesis of the soft elastomeric particles

Conventional radical emulsion polymerization

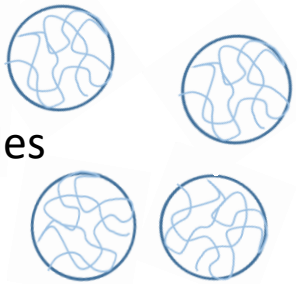
in water



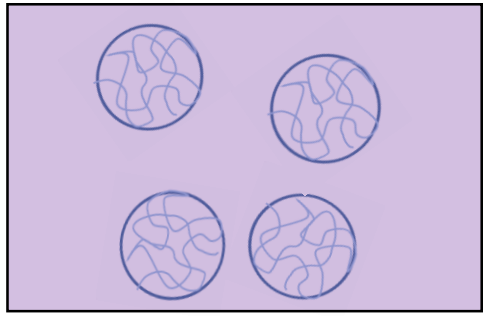
Crosslinked particles of elastomer

Various crosslinker contents

Dry particles



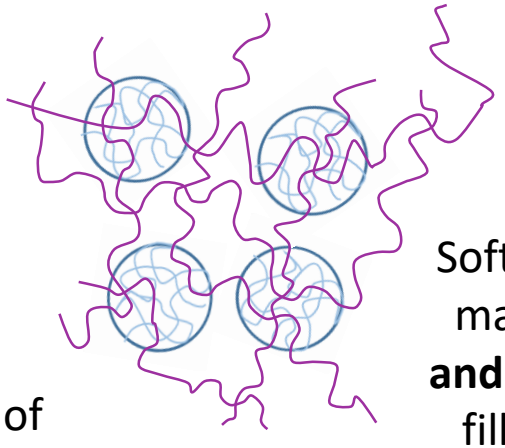
Dispersion and **swelling** of the dry particles **in monomer**



Various particle contents

Synthesis of the matrix

Conventional radical bulk polymerization



Soft elastomeric matrix **around and inside** of the filler particles

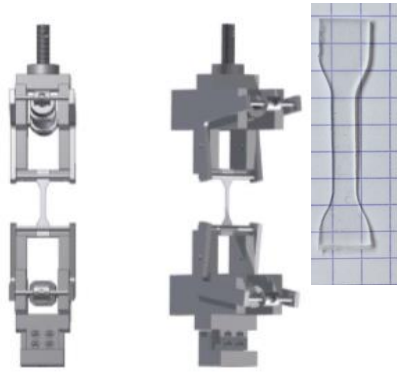
Transparent

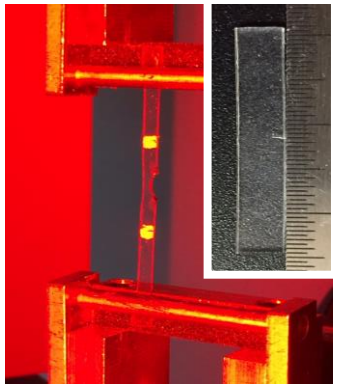
Same chemical nature between fillers and matrix
Same density
Easy dispersion of the fillers

Transparent

Does it work

Mechanical tests





- **Uniaxial extension**

Young's modulus, stress at break

- **Cyclic loading**

Viscoelastic energy dissipation or irreversible damage

- **Fracture propagation**

Toughness

What will happen to the mechanical properties of the material ?

How does the soft fillers change the mechanical behavior of the matrix ?

Will elastomers resist fracture propagation better with soft fillers ?