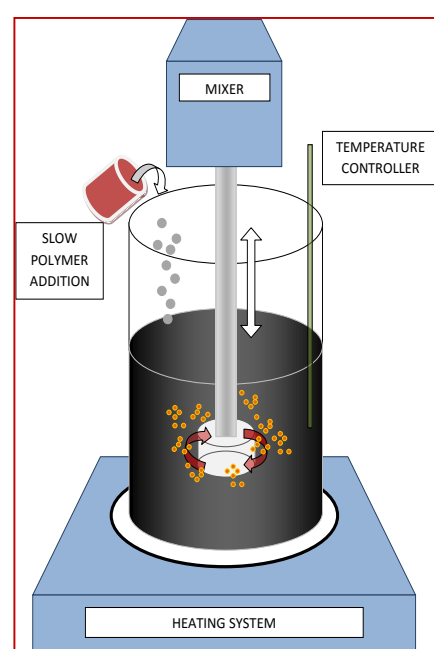




## Which EVA properties do favor milder processing in the production of PMB without sacrificing performance?

Two EVA parameter have been studied

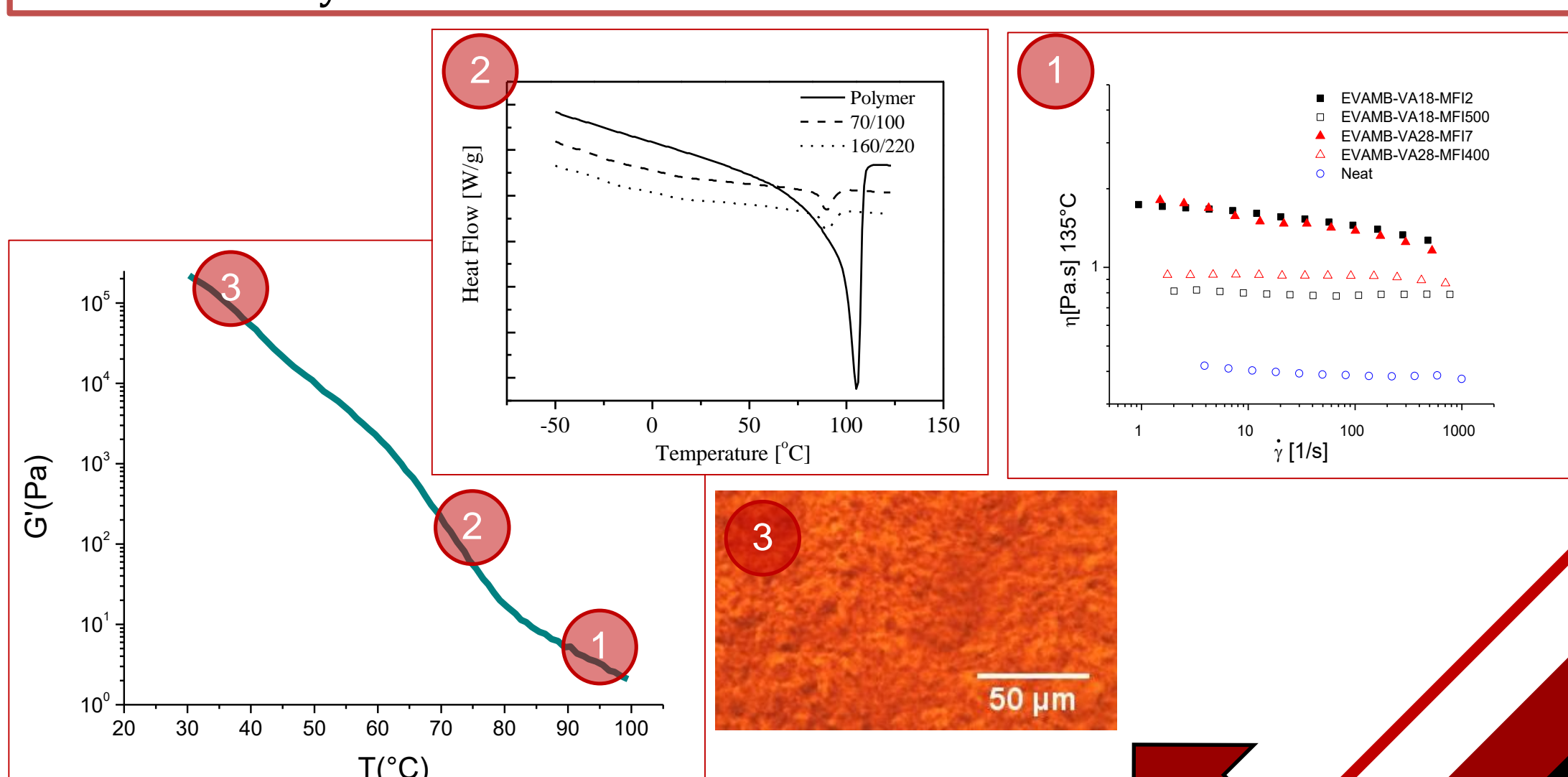
- Copolymer melting point (VA content : 7, 18, 28 and 33 %)
- Melt flow index (2, 7, 45, 400, 500 and 800 g/10m)



Experimental performed

- Technological test (Penetration, Ring and ball softening point test)
- Rheological characterization (Steady shear intermediate-high T, Oscillatory shear intermediate-high T, Dynamic torsion low T)
- Microstructural analysis in the binder and polymer (Thermogravimetric analysis, Differential scanning calorimetry, Microscopy)

Result summary

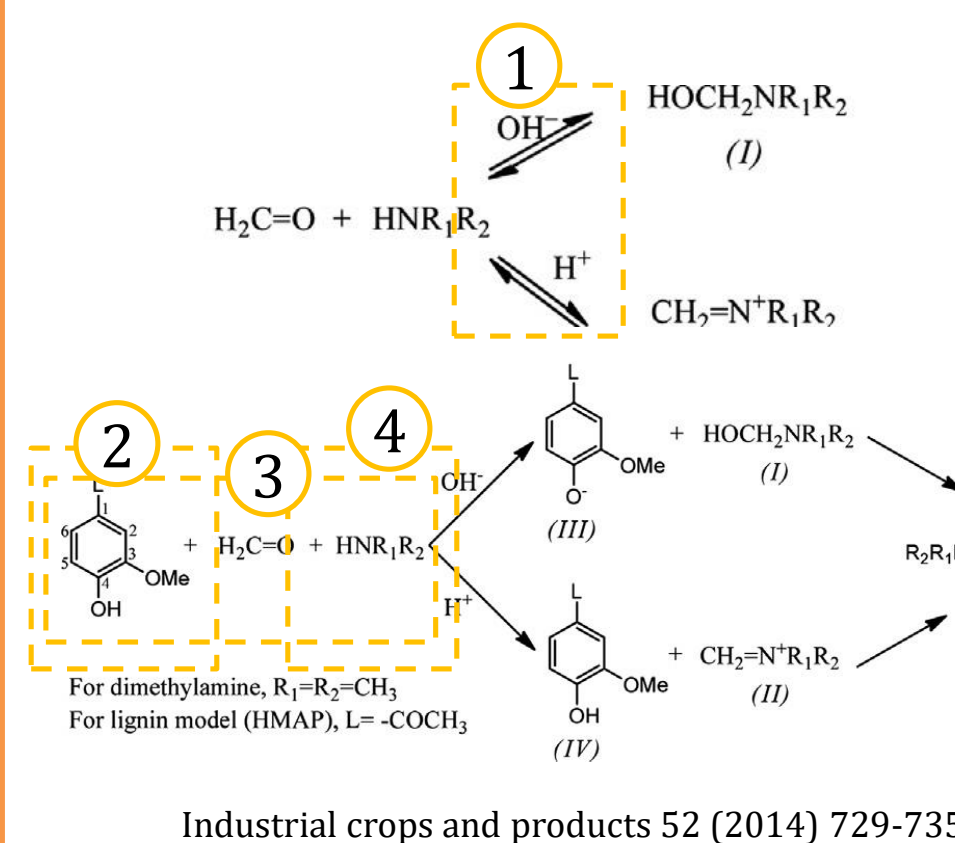


MFI is the key parameter for milder processing

## How to utilize by-product (lignin) of pulp industry? Development of lignin derivative cationic emulsifier

A specific objective of this section is to find an optimum way to manufacture lignin derivative product which can be used as cationic emulsifier. Mannich reaction was proposed as a method to enable lignin emulsifying properties, so that soluble in acidic environment, by attaching amine group

Experimental

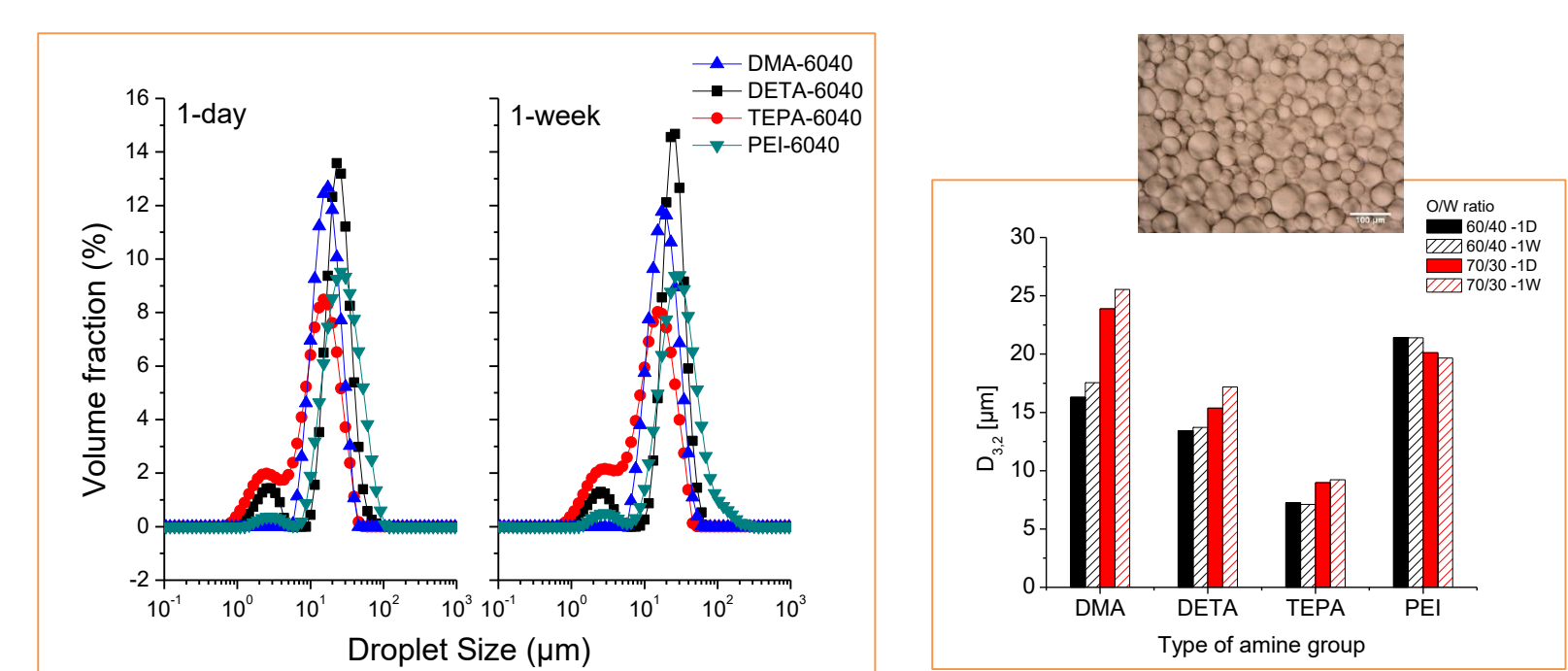


Preparation of emulsion prototype (silicon oil in water) by varying the following parameter

- Reaction route : alkaline - acidic
- Lignin type : kraft - bioethanol proc
- Reagent ratio of reaction
- Amine group type (2N to 5N)
- Emulsifier concentration (0.25 to 1.5)
- O/W ratio (50 to 70% dispersed phase)
- pH (1 to 11)

Stability and flow behavior evaluation based on evolution of DSD and viscosity curve

Result summary



Kraft lig. + TEPA in alkaline, for acidic use (optimum)

## Problem Statement

- Health and environmental issues associated to hot mixes uses (ie. higher toxic compound emission and higher energy consumption)
- Elevated temperature in the production of polymer modified bitumen
- Lignin as by-product of Kraft process from pulp and paper industry has not been commercially utilized, despite its high availability
- Reclaimed asphalt pavement

## Proposed idea

To enable sustainable aspect, with respect to environment, in the product design for road paving application

## Asphalt mixture with 100% RAP and emulsion in reduced temperature procedure

To manufacture and test (standardized for HMA) an asphalt mixes, prepared with Warm mix 120°C, Half warm mix 90°C, and Cold/mild warm mix 60°C procedure, containing 100% RAP

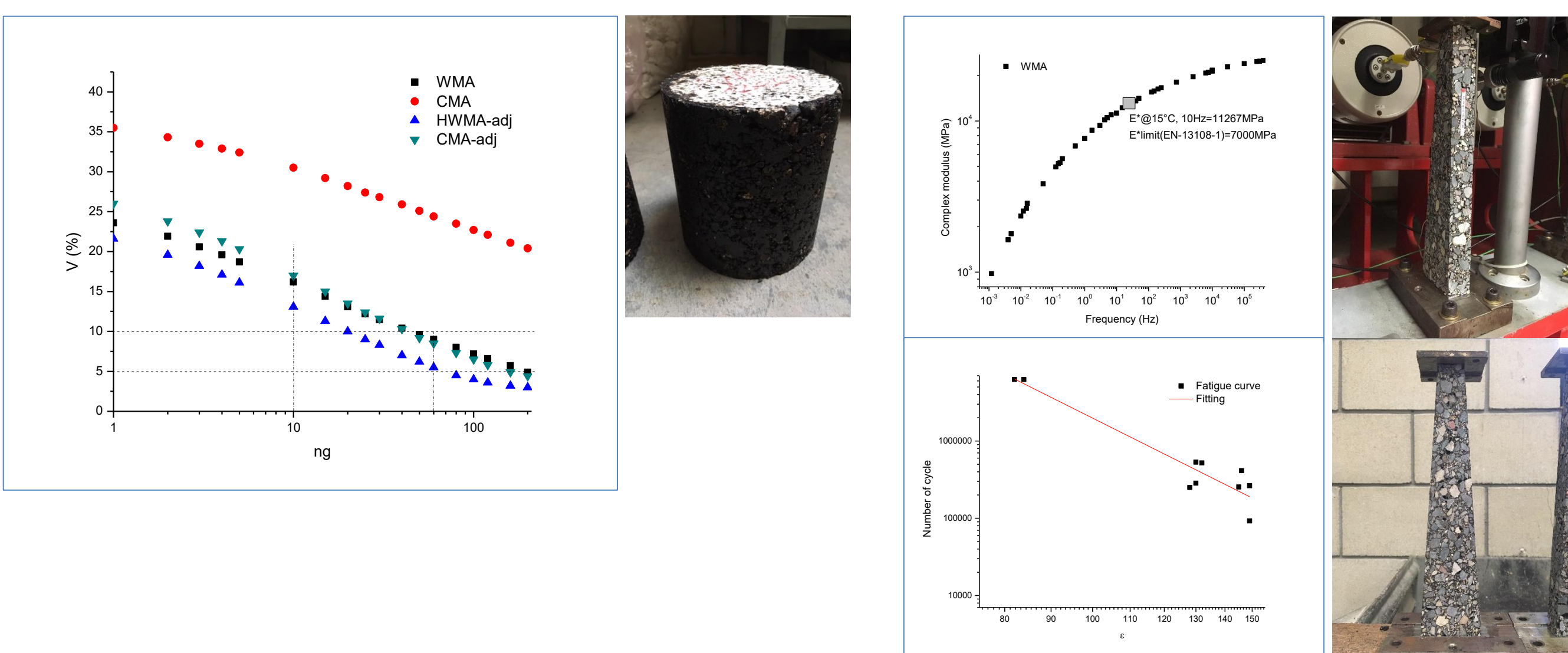
Experimental Preparation

Splitting RAP into 4 fractions aims to obtain a relatively close recomposed grading curve replication toward a specific design. Fresh bitumen added will then be adjusted depending on RAP binder content and temperature-related method used.

Tests

Gyratory compaction, water sensitivity (Duriez), wheel tracking (Rutting), complex modulus test and fatigue test

Result summary

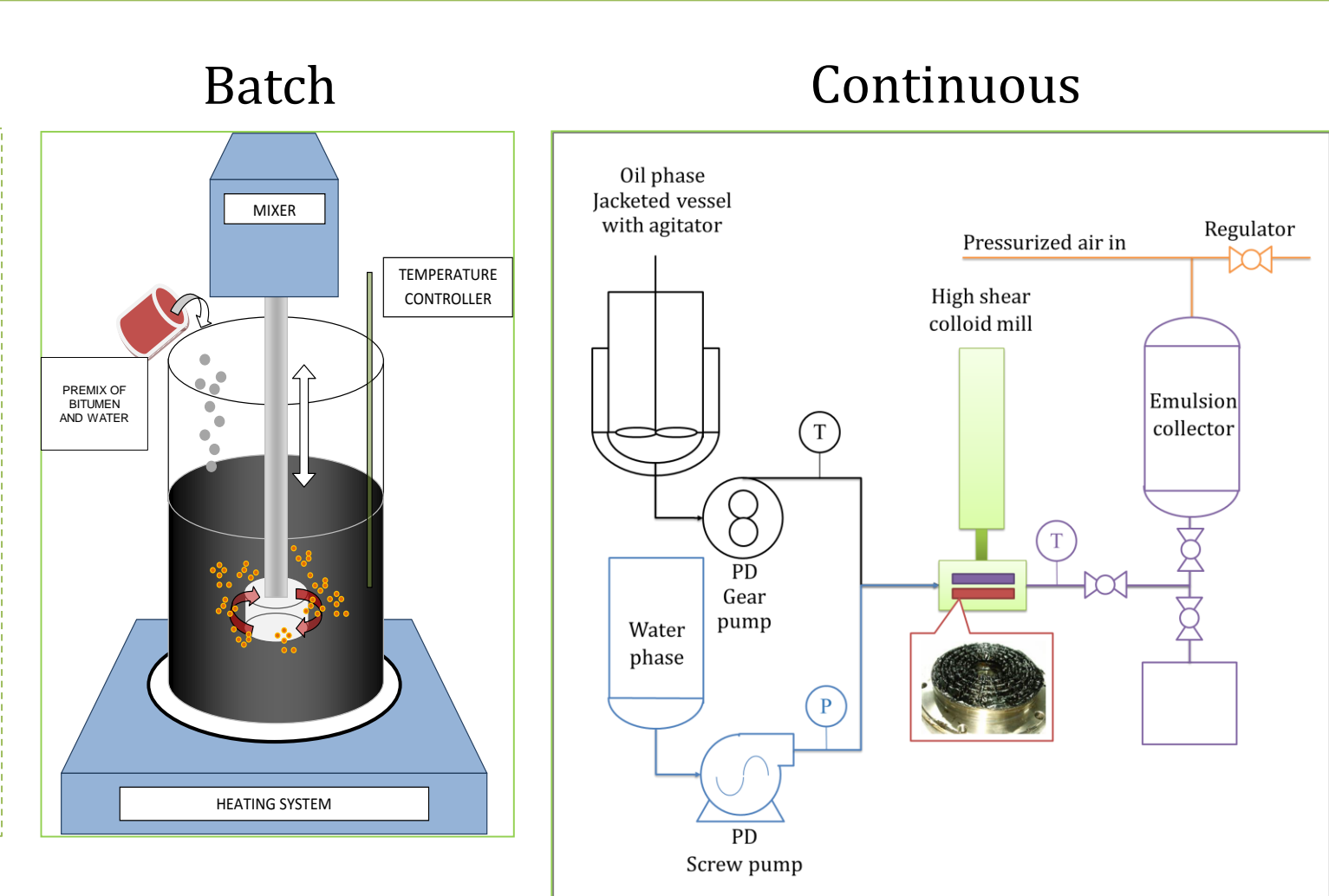


## Bitumen emulsion (or PMBE) with modified kraft lignin emulsifier

Flow behavior of emulsion and its residue is an important properties, when emulsion is applied during mixing with aggregate & when it is set for its final performance, respectively

Experimental

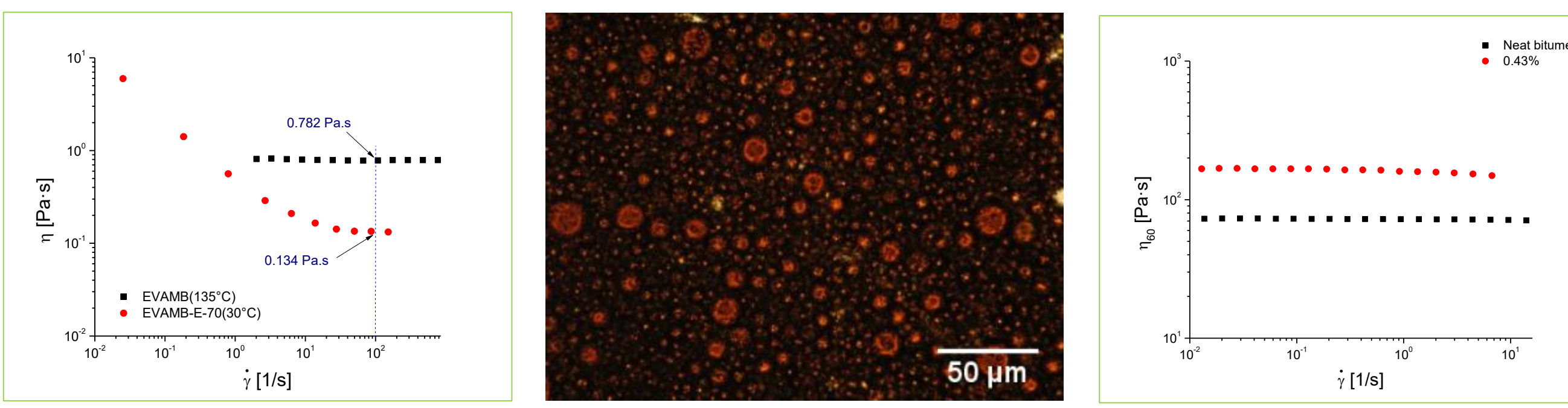
Preparation : Cationic emulsifier was dissolved in acidic aqueous phase prior to contact with bituminous phase in high shear rotating apparatus



Experimental (tests)

DSD and viscous flow tests were also performed for bitumen emulsion. In addition, flow behavior of the residual bitumen, obtained by evaporating the water, was also measured.

Result summary



For more details : A. Yuliestyan, A.A. Cuadri, M. Garcia-Morales, P. Partal, *j matdes* **96**, 2016, 180-188  
A. Yuliestyan, A.A. Cuadri, M. Garcia-Morales, P. Partal, *j trpro* **14**, 2016, 3512-3518



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