

ALTERNATIVE BINDERS TO PETROLEUM BITUMEN FOR ROAD CONSTRUCTION



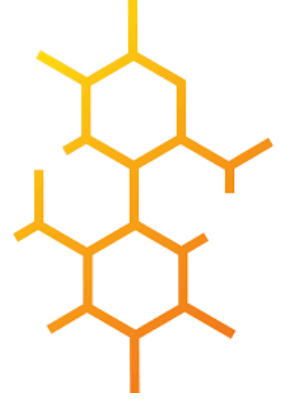
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Bitumen

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- Bitumen: derived from the distillation of petroleum (oil)
- Road bitumen consumption in France: 2.5 million tons in 2014
 - Roads (90%)
 - Waterproofing



Roads



Aggregates : 95%

+



Bitumen : 5%

=

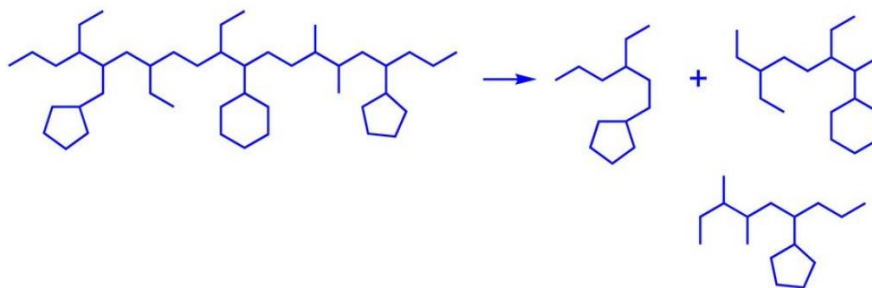


Bituminous mix

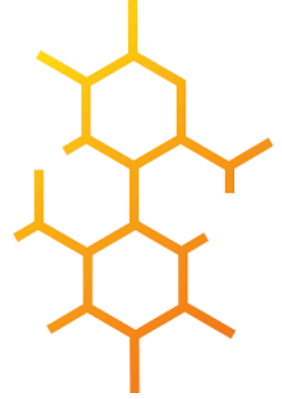
Why we should undergo researches and developments to replace petroleum bitumen and additives ?



- Oil: a non-renewable fossil fuel influenced by geopolitical and economic issues
- CO₂ emission from oil combustion : future regulation in Europe: new emission standard called Euro 7 is under development
- Petrochemical refining strategies: cracking of petroleum heavy fraction



What Alternative types is needed



- **Partial replacement**

- Extender (25 – 75%)
- Rheology modifier (< 10%)
 - Fluxant, Rejuvenator
 - Biopolymer
- Surfactant (< 1%)

→ Consistency close to bitumen

→ liquid with solvation effect

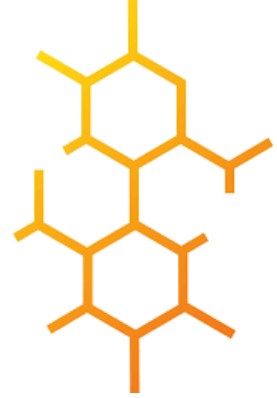
→ Elastic solid giving binder structuration

→ liquid with physico-chemical effect

- **Total replacement**

- Full replacement with virgin aggregates → Consistency close to bitumen
- Added binder in recycling technics (with the possibility to design a biobinder according to old bitumen rheological state) → Consistency close to bitumen

Biomass availability to replace petroleum bitumen ?



¹ 2019 - International bitumen emulsion federation

² <https://www.statista.com/statistics/263933/production-of-vegetable-oils-worldwide-since-2000/>

³ https://www.fao.org/3/i9166f/i9166f_chapitre4_Oleaginea_ux.pdf

⁴ Wan Nur Aifa Wan Azahar et al. / Jurnal Teknologi (Sciences & Engineering) 78: 4 (2016) 111–116

⁵ <https://www.gemme-la-foret.fr/chiffres.html>

⁶ Nicolas Scott Bentsen and Claus Felby 2010: Technical potentials of biomass for energy services from current agriculture and forestry in selected countries in Europe, The Americas and Asia. Forest & Landscape Working Papers No. 54-2010, 31 pp. Forest & Landscape Denmark, Frederiksberg

World production	Mt / year
Petroleum Bitumen ¹	111
Vegetal oil ²	200
Biodiesel from vegetal oil ³	20
Waste vegetal oil ⁴	10
Resin (colophane, tall oil) ⁵	1.2
Agricultural fresh residues ⁶	3300
Cellulose potential from agricultural residues ⁶	994
Current cellulose production from forests ⁶	386
Hemicellulose ⁶	618
Lignin ⁶	457
Wood used for energy ⁶	1300

! Figures need to be considered with caution – Consider order of magnitude !

Major actual supply sources

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- **At industrial scale**

- For total replacement
 - Pine chemistry (modified rosin)
 - Co-product from paper industry (tall-oil)
- For partial replacement
 - Pine chemistry
 - Pyrolyzed biomass
 - Vegetal oil from refinery process



- **Still at development stage**

- Thermochemical process able to liquefy biomass
 - Hydrothermal liquefaction of biomass like swine manure, agricultural, urban wastes, wood residues, but also microalgae
 - Pyrolysis
- Lignin as bitumen modifier
- Modified waste cooking oil

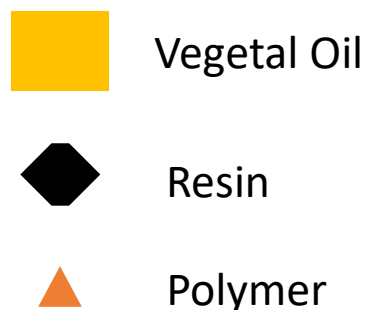
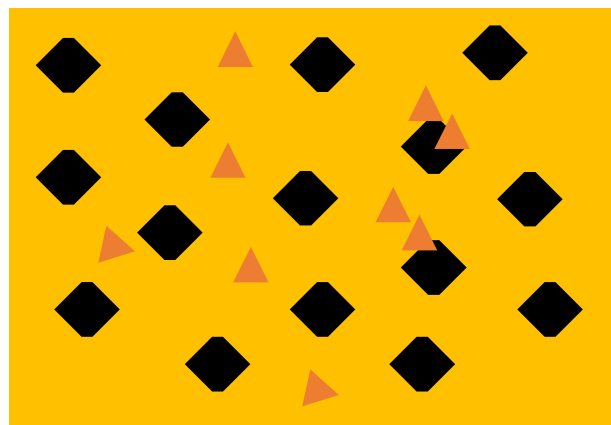


Examples

Binders developed by French road companies



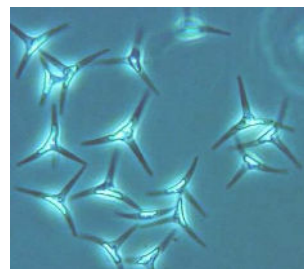
- **Vegecol[®], Séquoia[®], Floraphalte[®], Biophalt[®]**
 - Concept: vitrified/viscous particles in an oily matrix, structured or not by a polymer



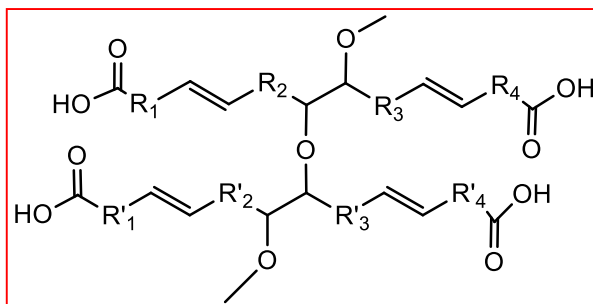
Examples

Algoroute project: long-term research

Microalgae residues valorization by solvent extraction



- Oily phase of microalgae is composed of fatty acid soup blended with a high resistant bio-polymer (Algeenan)
 - Yields could be between 10% and 30%



Examples



Algoroute project: long-term research

Microalgae residues valorization by hydrothermal liquefaction

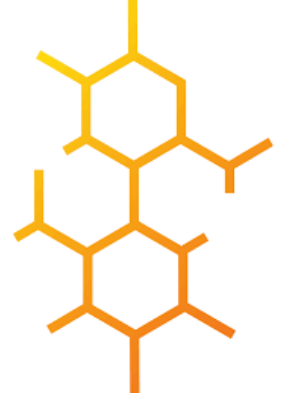
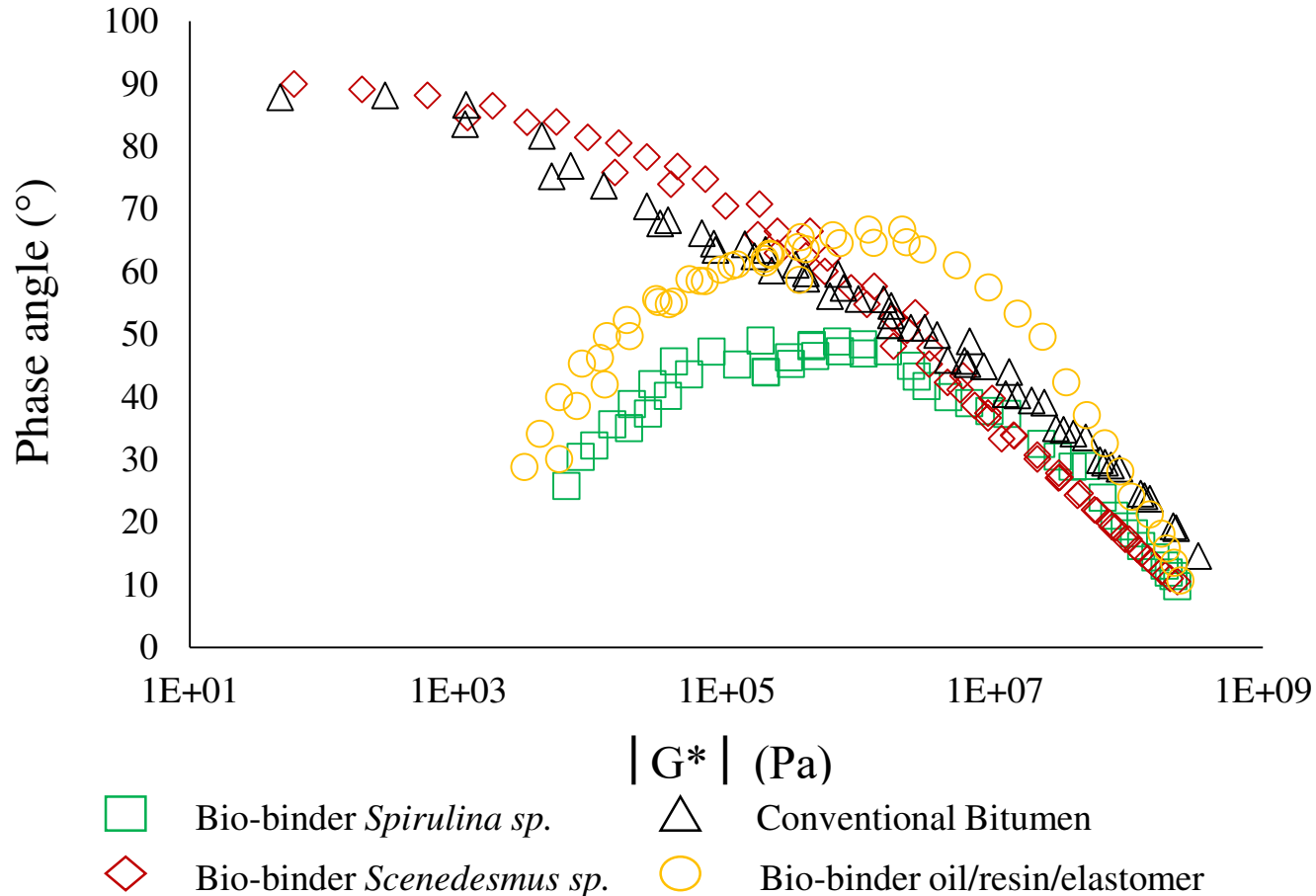
- Hydrothermal liquefaction: a process able to liquefy biomass using liquid water at hot temperature (300 °C) and high pressure (100-150 bar)
- Hydrothermal liquefaction of **microalgae residues** allows to recover **50%** of a **hydrophobic viscous material rheologically similar to bitumen**
- Worry about ecotoxicity of hydrothermal products (work in progress on this subject)



Examples

Algoroute project: long-term research

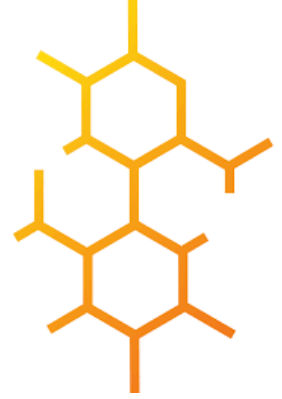
Bio-binder rheological assessment



Examples

Bitume 2.0 project: mid-term research

Use of biomass available in large quantity



1 - Valorization of biomass coming from agro-industry available in large quantity by hydrothermal liquefaction

Result similar to microalgae / Need to mix different type of biomasses to adjust the final rheology

2 - Valorization of used cooking oil

Chemical modification to increase viscosity: mimic the maltene phase
Physical modification to mimic to structuration given by asphaltenes

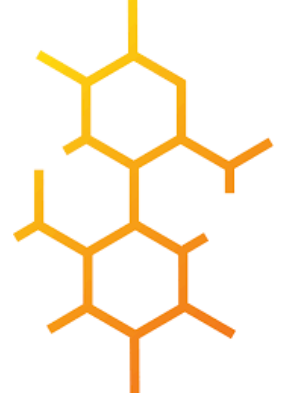
Lab properties of mix designed with modified used cooking oil are comparable with a BBSG Order 3 (french Spec)



Examples

BioRepavation project: short-term research

Evaluation of 3 alternative bio-materials for the recycling

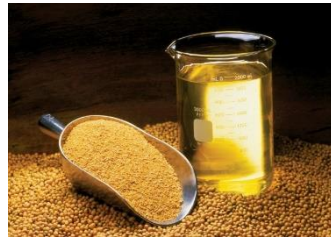


Sylvaroad™



or

Epoxidized methyl soyate



or

Biophalt®



+



As rejuvenator

As an extender

Old bitumen

Materials with biobinders behave better than conventional solution

- **Technical assessment**

- Demonstrator: UGE accelerated pavement testing facility
 - Distress mechanism monitoring
 - Innovative non-destructive method

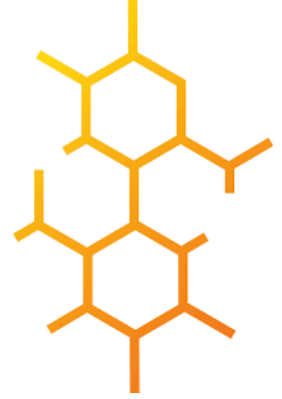
- **Environmental assessment**

- Life cycle assessment
- Fume emission measurements



Conclusion and perspectives

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Biomass: the futur for bitumen????

- Long term researches motivated by future petroleum exploitation context
- Mid and short term solution exist
 - Some full scale experiments show that it is possible to use biobinder
 - Mixing recycling technic and biobinder could be the solution of the future in our transportation infrastructure
 - We still need to identify new biomasses and new thermochemical processes in order to be able to replace a larger amount of petroleum bitumen
- Using biomass to make bitumen in place of energy valorisation “could be” environmentally beneficial

Acknowledgments

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