Materials

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Algoroute

Micro-algae to replace petroleum bitumen in our roads

At present, petroleum-based products are widely used to build roads, i.e. asphalt pavements. As aggregates blended with petroleum-based glue, they offer unequalled driving comfort on roads. In a post-petroleum world, what renewable alternative could our imagination produce? «Green» bio-sourced chemistry offers attractive options. Indeed, some totally or partially bio-sourced substitutes are already available on the market; but their availability in large quantities raises a difficulty! As with biofuels, will farming micro-algae allow us to upscale the production of new bio-sourced and renewable bitumen to be substituted for petroleum bitumen?

Algae binder recovery flask

Micro-algae farming offers a two-fold advantage versus aerial plant farming: it yields very large quantities of biomass and competes with no other crops ingested by humans. This has escaped neither biofuel manufacturers, nor producers searching for new food resources. The Algoroute Project seeks to maximise the value of the entire algal biomass. Having selected a protein rich variety (Scenedesmus sp by Alpha Biotech), the process involves recovering proteins for an initial use as food, then exploiting the manufactured residue by using fractionation and thermo-chemical technology.

The result is a hydrophobic (water repellent) and visco-elastic binder. This binder must ensure the cohesion of a granular environment whilst withstanding local stress, whether mechanical (traffic) or thermal (climate). In order to be fully substituted to bitumen in road coatings, this «plant polymer» must also have physico-chemical properties that will allow easy use, particularly the capacity to wet aggregates and coat them. It must also offer good long-term resistance and maintain granular structure cohesion in specific usage conditions (rigidity; resistance to cracking).

After three years of research at Ifsttar, hydrothermal liquefaction (HTL) was selected for the processing micro-algae biomass. More specifically, intense studies focused on conditions under which liquefaction occurred, that would result in a product with characteristics closest to those of petroleum bitumen. HTL mimics the conditions under which petroleum was naturally created (high pressures; high temperatures). It offers the advantage of taking place in an aqueous environment (water acting both as a solvent and a reagent). Unlike other more traditional heat conversion drying processes such as pyrolysis, this process calls for no prerequisite drying of the biomass (thus by-passing an energy intensive step). The bio-sourced material recovered through hydrophobic fractionation offers a thermo-mechanical behaviour that is quite similar to that of petroleum bitumen. And without drawing on any fossil resources! The net energy yield is already proving very promising. This innovative process has been patented.

Road coating material was then lab-produced using ordinary aggregates mixed in this «bio-binder». To the researchers' great surprise, the measured mechanical results showed greater resistance of this coated material versus more conventional road coatings; as for durability tests, they demonstrated that the bio-binder based coated material was more stable that conventional road coatings (exposure to UV (60 W/m^2) and to a flow of air at 60°C during 600 hours).

IFSTTAR

The technical and financial feasibility study led to modelling the hydrothermal liquefaction of micro-algae residue with a view to scaling up from lab production to industrial application. Mass-production cost assessments proved encouraging; obviously they are linked to the level of petroleum bitumen replacement in coated material. New openings are appearing that will maximise the use of hydrophobic fractionation to fulfil specific functions such as «adhesion enhancement».

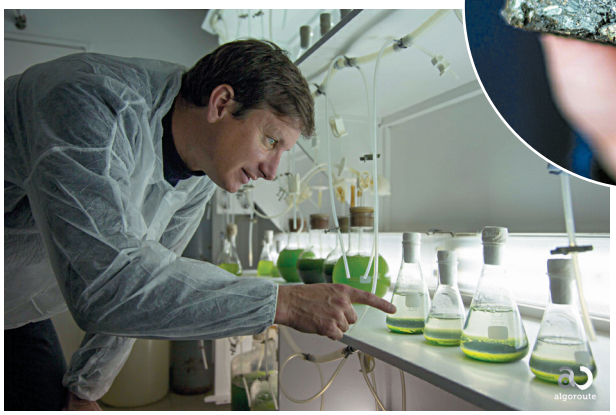
Ifsttar, jointly with the Algoroute Project (co-financed by the French administrative Region «Pays-de-la-Loire») have pooled regional competences drawn from the academic world (the research laboratories CEISAM[1] and GEPEA[2]) and the business world (AlgoSource Technologies and Alpha Biotech). For research to go on and prepare the industrialisation stage, the Algoroute Consortium filed a funding application with the French National Research Agency (ANR). Two new partners have joined in: Eiffage Infrastructure Groupe and IRCELYON Laboratory.

Research is now focusing on scaling up to the level of an industrially viable production of micro-algae. It is feasible to foresee driving on the first experimental algae-based road pavements in about ten years, once the last production and bio refining technological hurdles of this renewable resource have been cleared.

If 50% of the bitumen in road surfacing materials were to be subsisted for algae bitumen, and without even putting a figure on the advantage of recycling bitumen already used in roads, then close to 1 million tons in petroleum-based products could be saved every year in France.

[1] CEISAM : stands for Chemistry and cross-disciplinarity: synthesis, analysis, modelling
[2] GEPEA : stands for Laboratory for environmental and agro-food process engineering

A sample of coated material



Alphabiotec Laboratory - micro-algae farming

Open pond system - large scale micro-algae farming, developed by Alphabiotec

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