Skysong Innovations
Advancing the Arizona State University Knowledge Enterprise

1475 N. Scottsdale Road, Suite 200
Scottsdale, AZ 85287-3538
Phone: 480 884 1996 Fax: 480 884 1984

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Inventors

Elham Fini

Shuguang Deng

Contact

Shen Yan
shen.yan@skysonginnovations.com

Hybrid Asphalt Bio-Modifier Combining High-Protein and High-Lipid Feedstock

Background

Bitumen in asphalt pavement is subject to irreversible oxidative aging that results in unwanted stiffening and heightened risk of cracking. These conditions occur when the components within bitumen increase in polarity, causing agglomeration and forming nano-aggregates. Although modifiers have been successful in softening aged bitumen, the de-agglomeration of the polar molecules remains a key focus for advancing the effects of rejuvenation. Bio-modifiers including wood pellets, micro algae, waste cooking oil, corn stover, and swine manure, all provide varying levels of performance. In particular, swine manure has been shown to reduce the degree of agglomeration owing to its lipid content; and while the nitrogen-carrying compounds in swine manure contribute similarly, they also improve bitumen's moisture resistance. Hence, an opportunity exists for a hybridized bio-modifier to enhance these known effects beyond what can be achieved by manure alone.

Invention Description

Researchers at Arizona State University have developed a hybrid asphalt modifier for revitalizing aged bitumen. A hydrothermal liquefaction production process incorporates a balance of high-lipid swine manure and high-protein algae, which together maximize the formation of nitrogen-carrying molecules and deliver a high level of moisture resistance and de-agglomeration. This restores aged bitumen's molecular conformation, and thus its physicochemical and rheological properties. Both crossover modulus and frequency—prime indicators of aging—are improved with use of the hybrid modifier.

Use of this modifier in asphalt has also been shown to enhance pavement resistance to moisture damage even in cases involving the most notorious aggregate skeletons such as siliceous stones (e.g., quartz and granite). This is achieved by successfully passivating active sites of siliceous stones (Hung et al., 2019). For concrete, this modifier can serve as a superplasticizer to reduce the water-to-cement ratio and increase strength.

Potential Applications

- Asphalt and concrete rejuvenation

- Reclaimed asphalt pavement (RAP)

Benefits and Advantages

- Improves durability and service life – Provides both anti-moisture and rejuvenating properties
- Versatile – Can be used as a spray sealant or as a partial replacement (10-20% by weight of binder or 0.5-1% by weight of mixture)
- Environmentally friendly – Promotes resource conservation and feedstock does not compete with food sources

Related Publication: Investigation of Balanced Feedstocks of Lipids and Proteins To Synthesize Highly Effective Rejuvenators for Oxidized Asphalt

Related Publication: Improving recycled asphalt using sustainable hybrid rejuvenators with enhanced intercalation into oxidized asphaltenes nanoaggregates

Faculty Profile of Professor Elham H. Fini