Bio-Asphalt: An Innovative Pavement Material

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Table of Contents

Introduction

Asphalt concrete or hot mix asphalt (HMA) uses coarse aggregate, fine aggregate, and filler mixed in hot conditions. Since the early 1800s, asphalt roads have evolved into what we drive and commute on today. However, environmental concerns due to producing asphalt from petroleum have come to the forefront of discussions and continually develop into growing concerns. As noted in the 2018 publication by Dong, Ze-jiao, bio-asphalt binder for asphalt mixture pavement is made from sustainable materials as an alternative to conventional asphalt pavement layer. It eliminates many environmentally damaging processes that generally produce asphalt from petroleum. Since the early 2000, bio-asphalt has made significant strides in becoming a more environmentally friendly and reliable alternative to conventional asphalt concrete and HMA.

Objective

This research aims to understand the advantages of using bio-asphalt compared to a traditional asphalt mixture.

Background

Demand for asphalt in pavement construction, whether for maintenance, improvement, or development of road transportation, continues to increase along with the growth of the construction. However, concerns have continually risen with the increasing petroleum price in the last decade. Therefore, other alternative materials have been introduced as substitutes for conventional asphalt; asphalt is derived from bio-mass or often called bio-asphalt. The importance of environmentally friendly materials in today's transportation infrastructure industry cannot be overemphasized due to the increasing importance of limiting fossil fuels and ensuring

carbon emissions are decreasing. Energy-efficient and environmentally friendly asphalt materials are gaining popularity in recent decades due to diminishing energy resources, rises in dumping costs, environmental pollution, continuous pressure on landfills, and increasing asphalt binder prices. Reclaimed Asphalt Pavements (RAP) and Recycled Asphalt Shingles (RAS) have also risen in popularity as they preserve raw materials, provide an economic benefit through material cost savings, and improve material performance, significantly reducing the amount of materials being wasted in landfills throughout the world.

Materials/Ingredients

Bio-asphalt binder for asphalt mixture pavement is made from sustainable materials to conventional asphalt pavement layers. The materials used in bio-asphalt are also cheaper and available in sufficient quantities. Mixtures of bio-asphalt are viscoelastic material, which is further explained by the tendency of the mixture as it would behave as an elastic material at low temperatures and as a viscous material at high temperatures. These materials could consist of anything from straw, olive pits, and nutshells, along with many more possible materials. While miscanthus (silvergrass) and sorghum (grain) are also being investigated for use as bio-asphalt. Many different types of bio-asphalt vary in materials and how they are produced. As seen in Figure 1., the difference in production between corn- (DC) and castor-based (SH) bio-asphalt is ubiquitous throughout the process. This also signifies bio-asphalt variability as not all bio-asphalts are made the same, using the same ingredients.

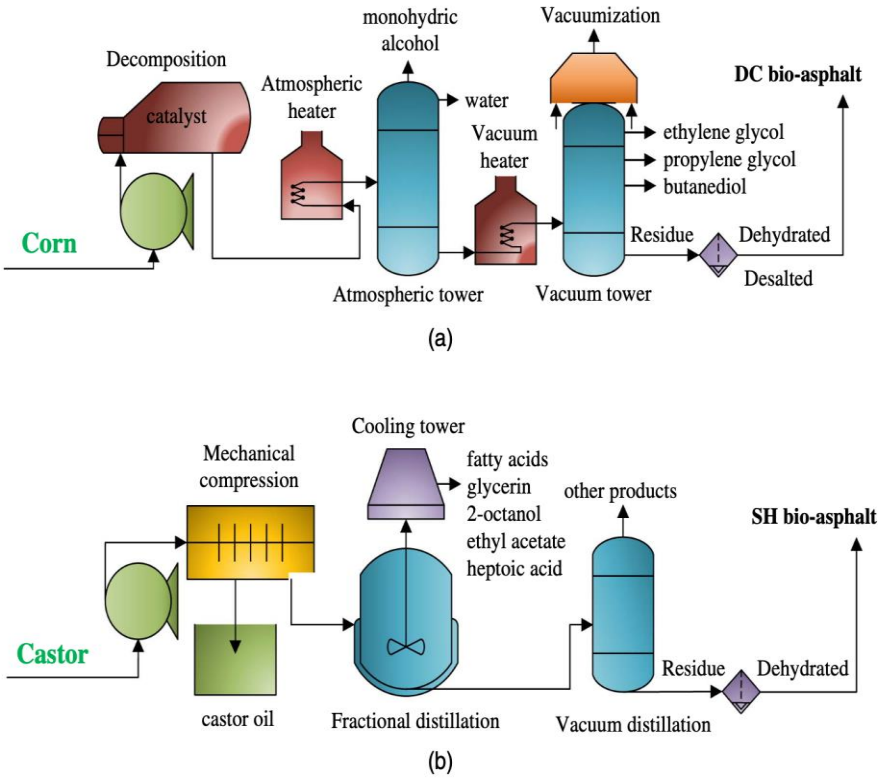

Fig. 1. Processing technologies of bioasphalts: (a) DC bioasphalt; (b) SH bioasphalt

Lab Testing

As seen in Figure 2., a lab test was conducted in which a blend of bio-asphalts was subjected to the basic properties tests of penetration, softening point, and ductility. As referred to in (Dong, Ze-jiao), according to the requirements of Chinese specification JTG F40-2004 (Ministry of Transport of the People's Republic of China 2004) for the binder PEN 90 (Penetration Grade 90), the softening point should not be less than 42°C, and the ductility at 10°C should not be less than 20 cm. According to the testing results of the basic properties, the optimum content of the bio-asphalt was 10% for DC (blended asphalt containing 10% DC bio-asphalt) and 15% for SH (blended asphalt containing 15% SH bio-asphalt).

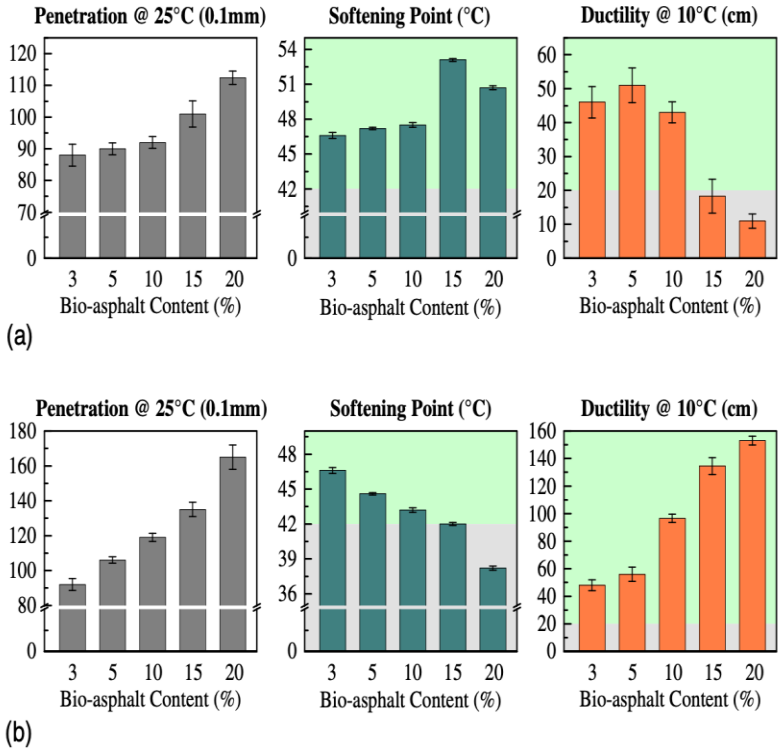

Fig. 2. Basic properties of the blended binder with different bioasphalt content: (a) blended DC bioasphalt; (b) blended SH bioasphalt

Performance

Material Strength

Bio-asphalt binder for asphalt mixture pavement is made from sustainable materials to conventional asphalt concrete pavement. In a 2011 publication, (Fini, Elham H) investigated the aging property of bio-asphalt from swine manure, corn stover, miscanthus pellets, and wood pellets using a binder aged by the Rolling Thin-Film Oven (RTFO) and Pressure Aging Vessel (PAV) tests. The results showed that the swine manure-based bio-asphalt had the lowest aging index, followed by corn stover and miscanthus pellets, and the bio-asphalt from wood pellets illustrated the highest aging index. This information signifies that most bio-asphalt does not work the same or have equivalent properties and material strength. Therefore, the correct type of bio-

asphalt would have to be determined by the atmosphere and environment the bio-asphalt is being put into.

Field Performance

The aging susceptibility of bio-asphalt has been investigated, and the results indicate that bio-asphalts are more prone to aging than their competitor, petroleum-based asphalt. In these scenarios, this signifies the increase in cracks, as there is a direct correlation to the aging of asphalt and the number of cracks that form at the surface. The primary purpose of using recycled materials is to save natural resources, and the other is that it is considered more economical and environmentally friendly. Based on this, it is necessary to find an innovative alternative that is environmentally friendly and economical. Bio-asphalt could replace petroleum-based asphalt due to its renewability and environmental friendliness, as bio-asphalt is made from different raw materials or processing technologies that have different properties and performance. However, bio-asphalt cannot wholly replace petroleum-based asphalt at this time due to bio-asphalts inconsistent softening points and lack of testing.

HMA with Bio-Asphalt Vs. Conventional Asphalt

Bio-asphalt-based HMA requires a higher production temperature. A lower production temperature results in reduced fuel consumption, reduced greenhouse emissions, and improved job site conditions for workers. Lower production temperatures also reduce the initial aging of the binder, which can improve long-term durability and pavement performance. The oxygen content, which is the main factor related to aging, of bio-asphalt is significantly higher than that of petroleum-based asphalt. Furthermore, the bio-asphalts from the pyrolysis of bio-mass and

processing residues of crops always contain hydrophilic groups such as acids, alcohols, saccharides, aldehydes, etc., which increases aging in bio-asphalt based HMA.

Conclusion

Bio-asphalt is the future. From its ability to use renewable energy and reusable resources to the idea of minimizing harmful gases and chemicals, bio-asphalt is the clear choice over conventional hot mix asphalt. However, bio-asphalt still needs to be perfected as more tests need to be completed to tackle multiple problems that arise with the production of bio-asphalt.

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