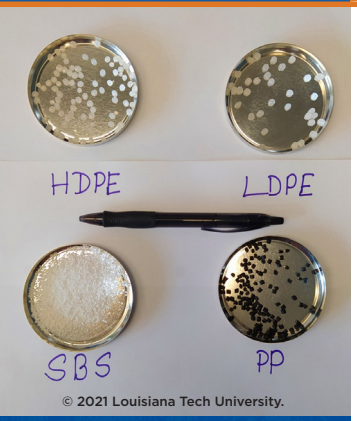
Improving the Compatibility of Waste

Exploratory Advanced Research…Next Generation Transportation Solutions



This photo shows different processed industrial waste plastic (HDPE, LDPE, SBS, and PP) used in this study.

Waste plastic, though largely considered an environmental concern, has the potential to be a valuable resource. Some researchers have proposed mixing waste plastic with asphalt binder to make asphalt for the Nation's roadways. Use of waste plastics to supplement traditional asphalt binders can reduce resource consumption and become an alternative to the disposal of waste plastic in landfills. However, challenges exist with using waste plastics in asphalt. In particular, knowledge of the compatibility of waste plastic—and the different types of polymers waste plastic is made of—with asphalt binders is limited. The Federal Highway Administration's (FHWA's) Exploratory Advanced Research (EAR) Program is supporting a 3-yr project, the first of its kind, to investigate and develop a computational model that can understand—on a molecular and atomic level—which waste polymers are compatible with which given asphalt binders to optimize the blend's performance. Through this computational model, the researchers aim to provide a foundation for utilizing waste plastic in asphalt pavements on an industrial scale. A research team at Louisiana Tech University is conducting this study, awarded in September 2020, titled, "Improving the Compatibility of Waste Plastic and Asphalt Binder Via Theoretically Justified Identification of Compatible Blends."

CURRENT STATE OF POLYMER COMPATIBILIZATION

Mixing polymers with asphalt binders for asphalt pavements is already a common practice. Polymers called poly(styrene-butadiene-styrene), also known as SBS, are highly compatible with asphalt binders, enhancing the strength of, and preserving high and low temperature behavior in, asphalt. The low temperature performance of SBS-asphalt blends comes from the softer binders that are used with the SBS-asphalt blends. SBS largely stiffens the asphalt binder, enhancing the high temperature performance and mitigating crack propagation. Crumb rubber, small particles of tire rubber, are also used to produce polymer-modified asphalt.

In contrast, polymers of postconsumer plastic do not mix well with asphalt binders due to their high molecular weight and low polarity. In addition, not much is known about which waste polymers are compatible with which asphalt binders.

Approaches for enhancing waste plastic's compatibility with asphalt binders have been investigated with varying degrees of success over the past 20 yr. However, they lack fundamental insight into how to optimize compatibility between mixes of waste plastics and asphalt binders.

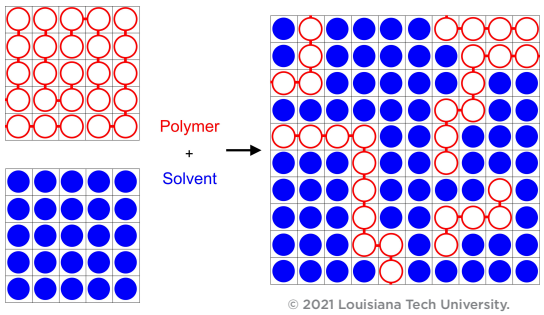
OVERVIEW OF RESEARCH PROJECT

The research project aims to gain a systematic understanding of waste plastic-asphalt binder compatibilization. The study consists of four main tasks: running simulations; preparing compatible waste plastic-asphalt binder blends; conducting performance tests; and identifying mechanisms and methodologies for improving compatibilization blends. Through this project, the researchers plan to develop screening tools that can predict the compatibility of various waste polymers and asphalt binders before mixing; identify and optimize the most promising approaches to waste plastic-asphalt binder compatibilization; understand the mechanism of compatibilization between waste polymers and asphalt binders; and develop a coarse-grained (CG) molecular model of waste plastic-asphalt binder blends.

Simulation Studies

Through a rigorous literature review, researchers will evaluate existing waste plastic compatibilization approaches that have demonstrated promise in the literature review and select several for analysis.

The researchers will then systematically examine the compatibility of a large array of possible waste plastic-asphalt binder blends, measuring each blend's estimated miscibility (the degree to which two substances can be fully mixed together). For blends that demonstrate strong estimated compatibility, the research team will use computer technology to apply atomistic



This figure shows the model used to calculate the compatibility of different polymers and asphalt (the "solvent" in the figure).

U.S. Department of Transportation
Federal Highway Administration

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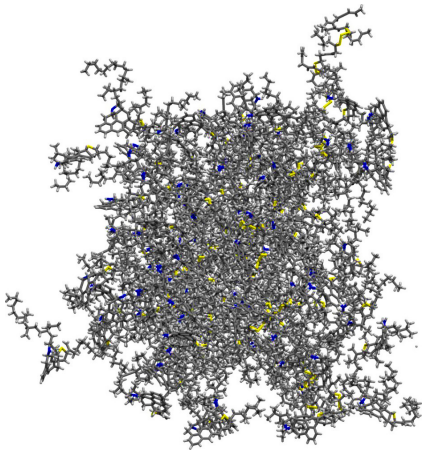

This figure shows an example of an atomic-level simulation used to calculate the interactions between polymer and asphalt binders.

modeling (modeling the blends at an atomic level) and CG modeling (a simplified model which allows the study of slower and larger scale effects). Such simulations can help researchers understand the structure and a variety of important physical properties of each optimal waste plastic-asphalt binder blend. This knowledge can be used to create tests for optimizing a waste plastic-asphalt binder blend prior to mixing.

Preparation of Compatibilized Blends in the Laboratory

Based on the simulation studies and the information gathered from them, waste plastic-asphalt binder blends will be developed. These prepared blends will be used to test the information gathered and determine how well the previously developed models and guidelines work.

This photo shows floating plastic particles on the surface after being added to a blend.

EXPLORATORY ADVANCED **RESEARCH**

What Is the EAR Program?

The EAR Program addresses the need for longer term, higher risk research with the potential for transformative improvements to transportation systems. The EAR Program seeks to leverage advances in science and engineering that could lead to breakthroughs for critical, current, and emerging issues in highway transportation by experts from different disciplines who have the talent and interest in researching solutions and might not do so without EAR Program funding.

To learn more about the EAR Program, visit https://highways.dot.gov/research/exploratory-advanced-research. The website features information on research solicitations, updates on ongoing research, links to published materials, summaries of past EAR Program events, and details on upcoming events.

Analysis of Waste Plastic-Asphalt Binder Blends in the Laboratory

A series of tests will be run to examine certain characteristics of the waste plastic-asphalt binder blends, providing information on how well the different waste plastic-asphalt binder blends may perform in roadways.

PROJECTED OUTCOMES OF STUDY

Much of the study's final product will be released as peer-reviewed conference and journal articles. By the end of the study, the project team anticipates producing four to six peer-reviewed conference publications and five journal articles for submission. Also, the CG models created will be made accessible to other researchers through common molecular dynamics software. The researchers also plan on reaching out to local Louisiana companies that produce asphalt to apply their knowledge from this study to the private sector.

LEARN MORE

For more information about this EAR Program project, please contact Jack Youtcheff (**202-493-3090**, jack.youtcheff@dot.gov) or Nusnin Akter (**202-493-3532**, nusnin.akter@dot.gov) in the FHWA Office of Infrastructure Research and Development.

FHWA-HRT-21-084
HRTM-20/08-21(WEB)E

Recommended citation: Federal Highway Administration, *Improving the Compatibility of Waste* (Washington, DC: 2021) https://doi.org/10.21949/1521670