National Center for Asphalt Technology NCAT at AUBURN UNIVERSITY

Plastics-in-Asphalt 101: "What is Viable"

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Just Another Acronym…

- **RPM = recycled plastic modified**
- RPM asphalt binder
- RPM asphalt mixture

BMD

Balanced Mix Design — Bring Me Donuts

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Background

- In late 2016, media reports in the U.S. started to advertise the use of recycled plastics in asphalt
  - Eliminate the growing amount of waste plastics
  - Improve the performance of asphalt pavements
- Since then, the "plastic roads" concept has gained increasing attention
- What's missing?

Literature Review

- What has been done in the past
- What needs to be done in the future

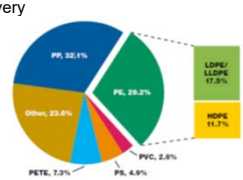
NAPA NATIONAL ASPHALT PAVEMENT ASSOCIATION

asphalt institute

NCHRP NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

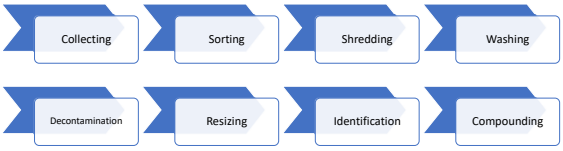
Availability of Recycled Plastics

- EPA data in 2018: 35.7 million tons of waste plastics generated, accounting for 12.2% of municipal solid waste generation
  - 3.1 million tons recycled
  - 5.6 million tons combusted with energy recovery
  - The rest landfilled
- 8.7% overall recycling rate
  - Vary greatly among different types of plastics
  - 30% for plastic bottles (PET and HDPE)

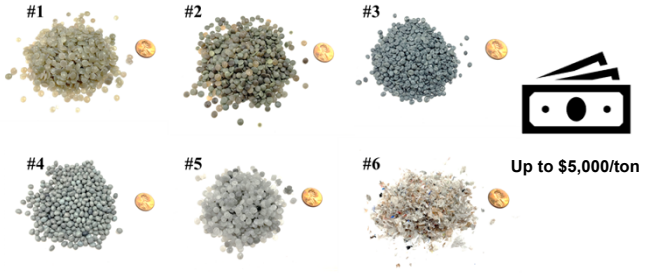


Sourcing of Recycled Plastics

- Post-industrial (PIR) vs. post-consumer recycled (PCR) plastics
  - PIR: manufacturing waste → "clean" plastic stream
  - PCR: end-of-life consumer item → "dirty" plastic stream
  - Processing efforts for recycling: PCR >> PIR
- Recycling of PCR plastics



PCR Plastic Samples in NCHRP 09-66



Characterization of Recycled Plastics

- Commonly reported properties in literature
  - Specific gravity
  - Melting temperature
  - Particle size
- Other properties possibly important for asphalt applications
  - Melt flow index
  - Degree of crystallinity
  - Ash content
- How these properties affect asphalt performance remains unknown
- No guidance on the selection of recycled plastics for use in asphalt

Methods of Adding Plastics

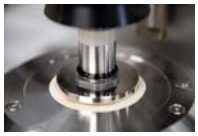
- Wet Process
  - Polymer modifier or binder replacement
  - 1 to 12% by weight of asphalt binder
  - Low melting point needed

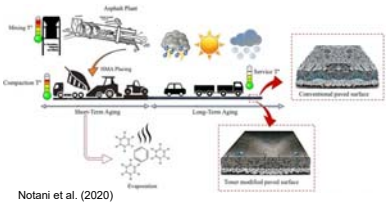
Methods of Adding Plastics

- Wet Process
  - Polymer modifier or binder replacement
  - 1 to 12% by weight of asphalt binder
  - Low melting point needed
- Dry Process
  - Aggregate replacement
  - Mixture modifier
  - Aggregate modifier
  - 0.2 to 6% by weight of aggregate

Asphalt Binder Characterization

- Overall stiffening effect
- Improved rutting resistance
- Very little data on fatigue, low-temperature, and aging resistance

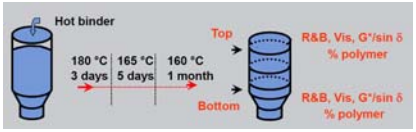




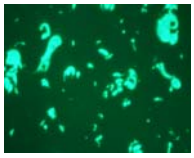
Notani et al. (2020)

Asphalt Binder Characterization

- Phase separation issue
  - Chemical incompatibility due to different solubility
  - High physical separation tendency due to different density
  - Cigar tube test
  - Fluorescence microscopy

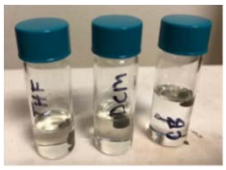


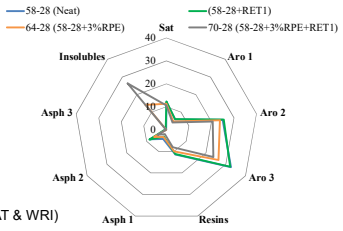
(Baumgardner and Planche, 2020)



Asphalt Binder Characterization

- Polyethylene (PE) insoluble in many solvents
- Insoluble fraction in SAR-AD analysis





(Data from PLASTICS study at NCAT & WRI)

Asphalt Mixture Characterization

- Increased Marshall stability
  - ≠ longer pavement life
- Increased stiffness and rutting resistance
- Little information on cracking resistance and moisture resistance
- High modulus mixture applications
  - Potential pavement thickness reduction benefits

Other Challenges

- Plant operations
  - High-shear blending unit for wet process
  - Additive feeding system for dry process
- Construction
  - Reduced mixture workability
  - Increased temperature susceptibility due to polymer crystallization below T_{melt}
- Health and safety concerns
  - Leaching of toxic components
- Environmental impact
  - Release of microplastics
  - Re-recyclability of asphalt pavements

RPM Field Projects (2018 to 2021)

MnROAD-NCAT Additive Group (AG) Experiments

- Evaluate sustainable and resilient pavement technologies including recycled plastic, rubber, synthetic fiber, and reactive polymer
- 6 Test Track sections evaluating fatigue cracking
- 7 MnROAD sections evaluating reflective cracking

MnROAD-NCAT Additive Group (AG) Experiments

- 2 plastic-in-asphalt technologies
  - Wet process: hybrid modification with PCR LLDPE and Elvaloy™
  - Dry process: drop-in modification with PCR LLDPE
- Comprehensive lab testing & simulations underway
- Field performance monitoring
  - After 3 million ESALs

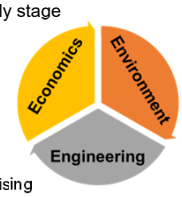
  - Stay tuned for more data

NCHRP 09-66

- Objective: evaluate the impact of post-consumer recycled plastic waste on the performance properties of asphalt mixtures when added using the dry process
- Specific scopes
  - Mixture performance characterization
  - Surface friction characterization
  - Fume emission evaluation
  - Mix design strategies to maintain balanced performance
  - Process control, production, and construction guidelines
- Phase I report available online
- Phase II in progress

Closing Thoughts

- 'Use of recycled plastics in asphalt' is still at an early stage
  - Comprehensive literature review available
  - Opportunities & challenges from the '3E' perspective
- Lessons learned from ongoing NCAT research
  - Plastics are rather complicated
  - Adding plastics do not always yield favorable results
  - Wet process
    - Hybrid modification with elastomer appears promising
    - Need to engineer binder formulation to ensure performance
  - Dry process
    - In general, improved rutting resistance but reduced cracking resistance
    - Volumetric analysis not sufficient to ensure performance → need BMD



Thank You

Questions?

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