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IACIP

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Investigating the storage stability of asphalt binder modified with treated high-density polyethylene (HDPE) using Fourier-transform infrared spectroscopy (FTIR)

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INTRODUCTION

- ❑ Million tons of plastics were disposed every year
- ❑ Incorporating waste plastics into asphalt mixtures is a way of recycling them
- ❑ A significant challenge of using the plastic-modified binder is its poor storage stability
- ❑ New methods of recycling HDPE in asphalt need to be developed and evaluated

OBJECTIVE

- ❑ To develop flame treatment and acid treatment methods to make plastic more compatible with asphalt binder
- ❑ To explore the feasibility of treated HDPE in improving modified asphalt storage stability

METHODOLOGY

Materials

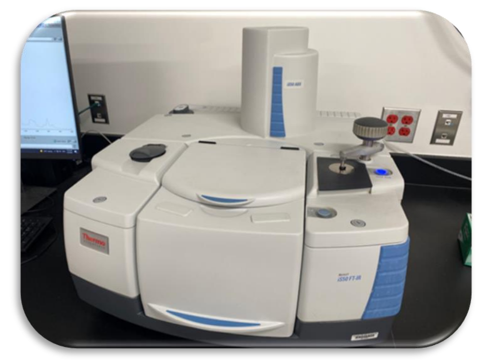
- ❑ Flame treated HDPE powder
  - ➢ To introduce oxygen-containing functional groups on plastic surface
  - ➢ Two parameters to control the quality and level of treatment: treating distance and time

- ❑ Acid treated HDPE powder
  - ➢ Sulfuric and nitric acid in different ratios and different treating durations

Characterizations methods

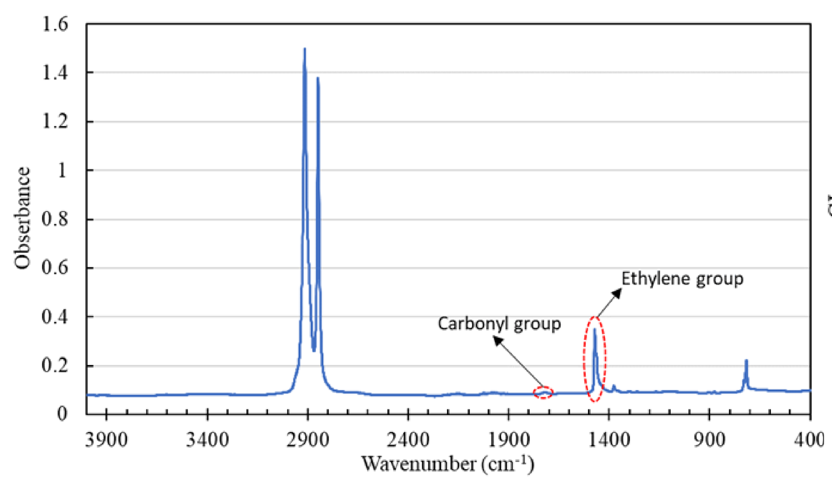
- ❑ Storage stability test

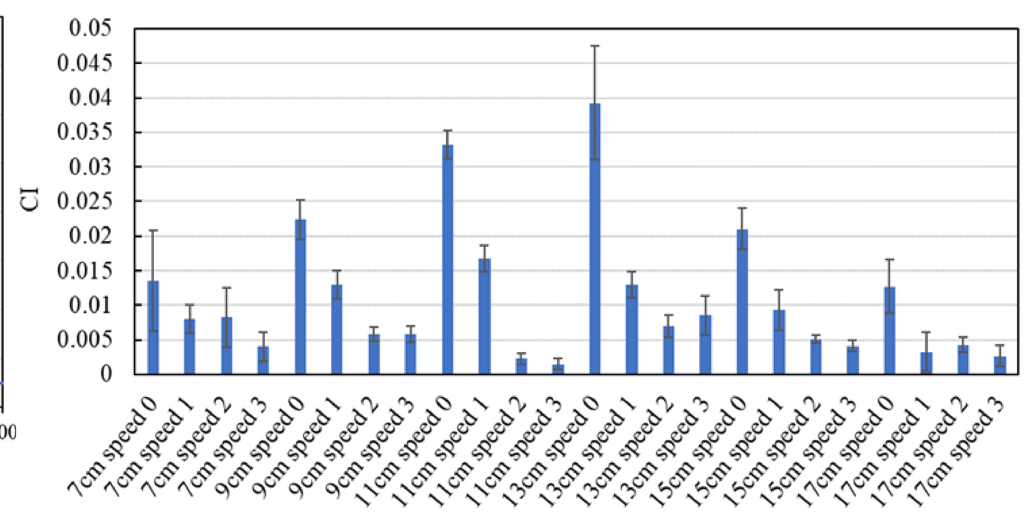
- ❑ FTIR test



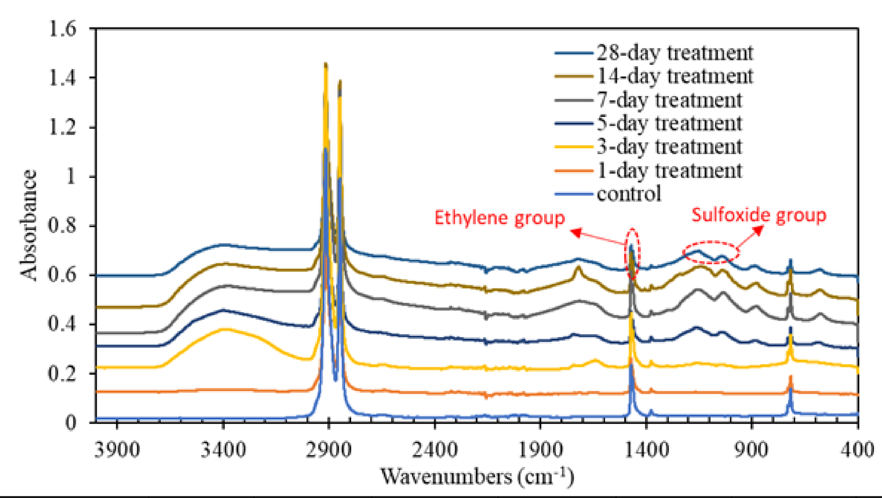
DETERMINATION OF OPTIMUM FLAME AND ACID TREATMENTS

- ❑ Effect of flame treatment on HDPE powder
  - ➢ Carbonyl group (C=O stretch) was the only new functional group generated after flame treatment
  - ➢ Carbonyl index (CI) = $A_{1720cm^{-1}}$ / $A_{1462cm^{-1}}$
  - ➢ 13cm speed 0 (0.33 seconds) was selected as the optimum treatment condition

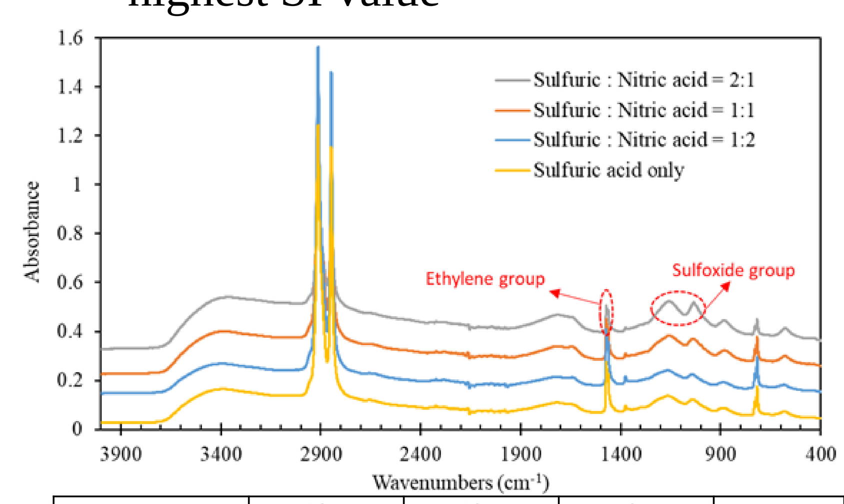




- ❑ Effect on acid treatment on HDPE powder
  - ➢ Sulfoxide group is the new generated functional group
  - ➢ Sulfoxide index (SI) = $A_{1031cm^{-1}}$ / $A_{1462cm^{-1}}$
  - ➢ SI increased with longer treatment durations
  - ➢ Sulfuric: nitric acid = 2:1 yielded the highest SI value



Treating time	Control	1-day	3-day	5-day	7-day	14-day	28-day
SI	0	0	0.3	1.0	1.7	1.8	1.8



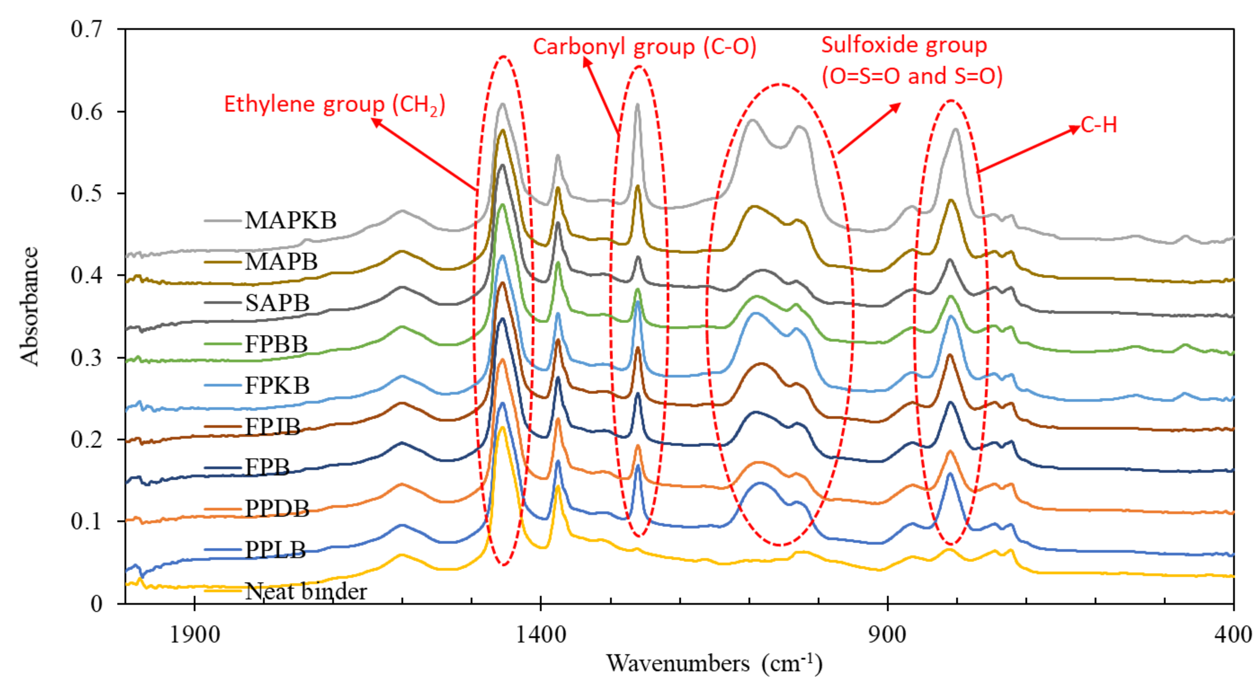
Acids ratios	Sulfuric: Nitric acid = 2:1	Sulfuric: Nitric acid = 1:1	Sulfuric: Nitric acid = 1:2	Sulfuric acid only
SI	4.1	3.4	1.8	1.7

RESULTS AND DISCUSSION

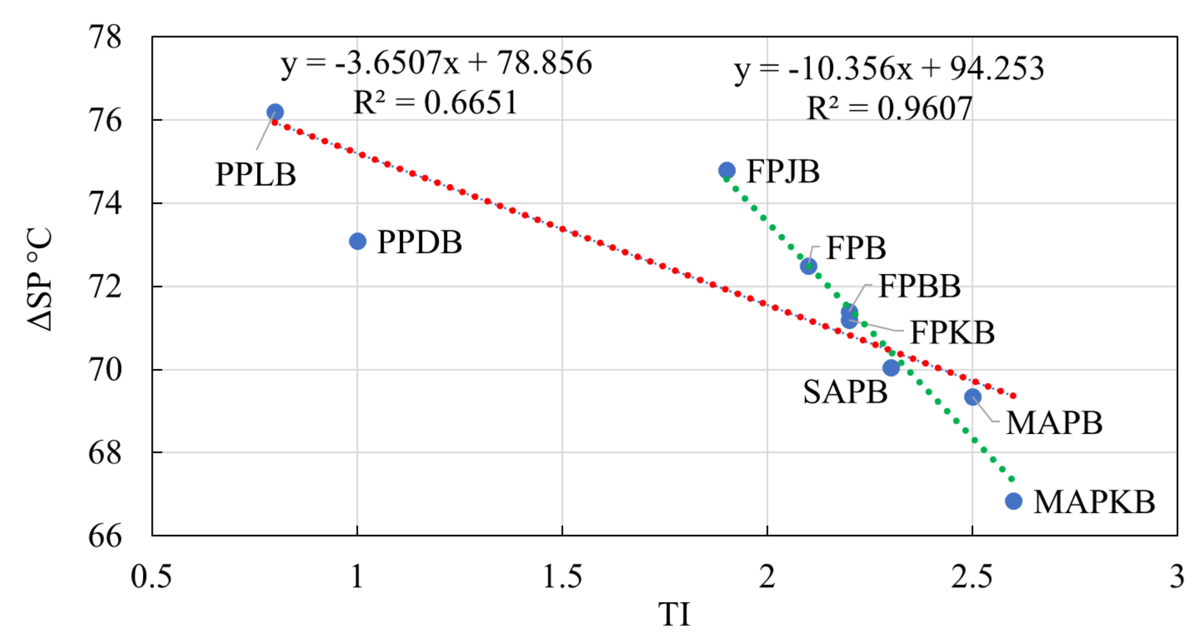
- ❑ All modified binders

Type of binder	Designation	Modifiers and dosages (wt./wt. of binder)
Plastic Pellet-modified Binder	PPLB	HDPE pellet: 5%
Plastic Powder-modified Binder	PPDB	HDPE powder: 5%
Flame-treated Plastic-modified Binder	FPB	Optimum flame treated HDPE powder: 5%
Flame-treated Plastic and Kaolinite-modified Binder	FPKB	Optimum flame treated HDPE powder: 5% Kaolinite clay: 2%
Flame-treated Plastic and Bentonite-modified Binder	FPBB	Optimum flame treated HDPE powder: 5% Bentonite clay: 2%
Flame-treated Plastic and Rejuvenator-modified Binder	FPJB	Optimum flame treated HDPE powder: 5% Rejuvenator: 5%
Sulfuric Acid-treated Plastic-modified Binder	SAPB	Optimum sulfuric acid treated HDPE powder: 5%
Mixed Acid-treated Plastic-modified Binder	MAPB	Optimum mixed acid treated HDPE powder
Mixed Acid-treated Plastic and Kaolinite-modified Binder	MAPKB	Optimum mixed acid treated HDPE powder Kaolinite clay: 2%

- ❑ FTIR results
  - ➢ Some new functional groups were generated (i.e., C-O stretching, O=S=O stretching, S=O stretching, and C-H bending)
  - ➢ Total peaks index (TI) = $\sum A_{multiple\ peaks}$ / $A_{1462cm^{-1}}$ (where, $\sum A_{multiple\ peaks} = A_{1250cm^{-1}} + A_{1100\ cm^{-1}} + A_{1020\ cm^{-1}} + A_{800cm^{-1}}$)



- ❑ Softening point test results
  - ➢ PPLB had the lowest TI, followed by PPDB (Size matters)
  - ➢ FPB has nearly doubled TI compared to PPDB (The flame treatment HDPE was more reactive)
  - ➢ Top sections exhibited much higher softening points than the bottom sections (Storage stability was not good)
  - ➢ SAPB, MAPB, and MAPKB showed better TI and than FPB
  - ➢ TI and ΔSP are highly correlated



CONCLUSIONS

- ❑ FTIR and storage stability tests had a high correlation
- ❑ Smaller sized plastic had better compatibility with asphalt
- ❑ Flame treatment and acid treatment both made HDPE powder more reactive
- ❑ Acid-treated HDPE powder is more compatible with binder than flame-treated HDPE powder
- ❑ Mixed Acid-treated Plastic and Kaolinite-modified Binder (MAPKB) is the optimum modified binder in terms of storage stability