Determination of the dispersancy of modified dispersants prepared from polyisobutylene terminated with succinic anhydride (PIBSA)

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Introduction

Succinimide dispersants are among the most important additives that are currently used in engine oils. They adsorb on the surface of carbon-rich particles generated during engine operation, stabilizing them in solution, and consequently reducing the emission of ultra fine particles (UFPs) and the formation of sludge. This research intends to study how efficiently a series of succinimide-based dispersants stabilize carbon-rich particles in engine oil.

Problems Caused by Combustion by-Products

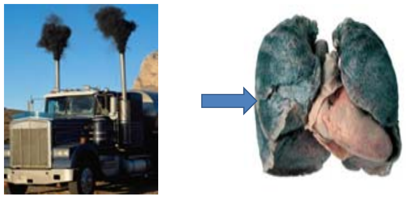


Figure 1. *Lung failure cause d by UFPs emission in to the air:*

UFPs are typically formed by the incomplete oxidation of fuel during ignition and can be released into the air. Since releasing UFPs from engines into the air can cause heart and lung failure, governmental regulations were issued to reduce their emission. This, in turn, results in higher concentrations of UFPs in the oil which lead to sludge formation. To prevent this phenomenon from happening, dispersants are added to the oil additives..

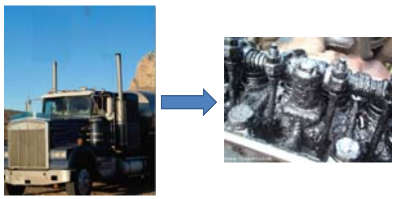


Figure 2: *Sludge formation caused by circulating the exhaust gas back into the oil.*

How to Prevent Sludge Formation

UFPs which are smaller than 100 nm in diameter, have polar groups on their surface which are generated by the oxidation of the oil during engine operation. In apolar oil, UFPs self–aggregate into large particles (LPs, d_{LP}= ~1 µm) to minimize their surface exposure to the oil.

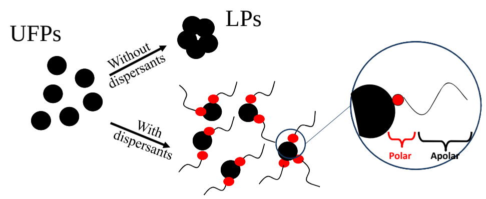
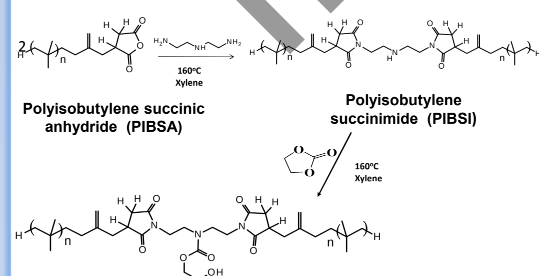


Figure 3. *UFPs in the oil (a) aggregated UFPs in the absence of dispersant; (b) stabilized UFPs in the presence of dispersant.*

LPs can cause sludge formation resulting in oil blockage and engine failure. Therefore, dispersants are added to the engine oil to minimize UFPs aggregation into LPs. Dispersants are typically composed of a polar head group and an oil-soluble apolar tail. The polar core of the dispersant is expected to be adsorbed onto the surface of the UFPs, whereas the apolar tail stabilizes the particle in the oil.

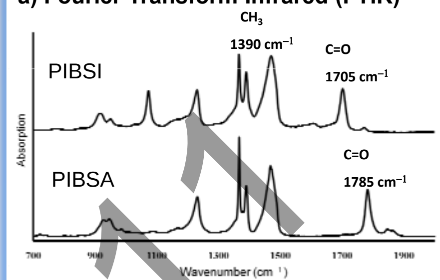
Synthesis Protocol of Succinimide Dispersants



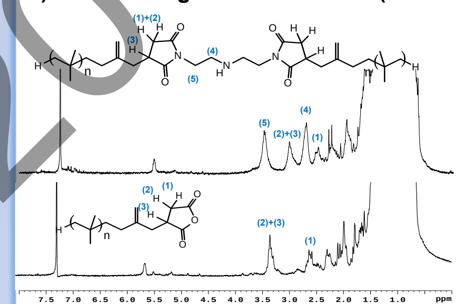
Diethylenetriamine (DETA)	$H_2N\text{-}CH_2CH_2\text{-}NH\text{-}CH_2CH_2\text{-}NH_2$
Tetraethylenepentamine (TEPA)	$H_2N\text{-}(CH_2CH_2\text{-}NH)_3\text{-}CH_2CH_2\text{-}NH_2$
Pentaethylenehexamine (PEHA)	$H_2N\text{-}(CH_2CH_2\text{-}NH)_4\text{-}CH_2CH_2\text{-}NH_2$
Hexamethylenediamine (HMDA)	$H_2N\text{-}CH_2CH_2CH_2CH_2CH_2CH_2\text{-}NH_2$

Determination of Chemical Composition

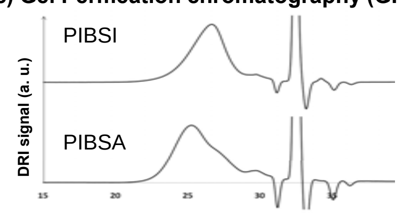
a) Fourier Transform Infrared (FTIR)



b) Nuclear Magnetic Resonance (^{1}H NMR)



c) Gel Permeation chromatography (GPC)



Preliminary Results

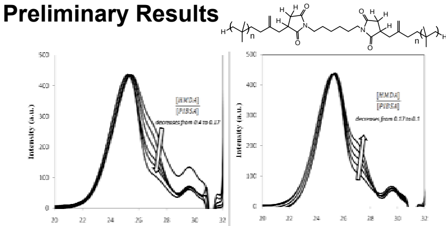


Figure 7. *GPC traces of b-PIBSI-HMDA*

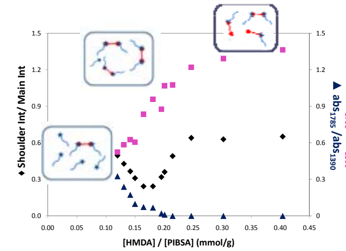


Figure 8. *FTIR and GPC intensity ratios versus [HMDA]/[PIBSA] ratio; abs_{1705}/abs_{1390} (■), abs_{1782}/abs_{1390} (▲), shoulder to peak intensity ratio (♦).*

Summary of Chemical Compositions

Dispersants		^{1}H NMR	FT-IR (Peak Height)	GPC
PIBSA	N_{SA} / N_{IB}	1:55 (Wang, Y)	1:49 (*Walch, E*)	1: 52
b-PIBSI	N_{SI} / N_{IB}	1:33±1 (Wang, Y)	1:34±1 (*Shen, Y*)	1:32

Walch, E.; Gaymans, R. J. *Polymer* **1994**, *35*, 1774-1778
Wang, Y., M. Sc. Thesis, University of Waterloo, 2010.
Shen, Y.; Duhamel, J. *Langmuir* **2008**, *24*, 10665-10673.

Modification

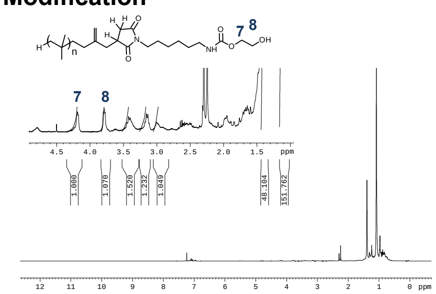


Figure 9 . ^{1}H NMR *spectrum of modified PIBSI-HMDA*

Summary and Future Work

- The chemical composition of PIBSA and PIBSI were determined.
- Successful ethylene carbonate modification was achieved for *mono* PIBSI-HMDA.
- Investigate the effect that the modification of the PIBSI dispersants can have on their ability to form micelles, and in turn, how it affects their ability to adsorb onto CRPs.

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