Introduction

Succinicimide 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 characterize the chemical composition of a series of succinimide-based dispersants. The chemical composition of polyisobutylene succinic anhydride (PIBSA) and a series of polyisobutylene succinicimide (PIBSI) dispersants were determined by more common characterization methods such as 1H NMR, FTIR, UV-Vis, and a procedure based on GPC analysis. Also steady-state and time-resolved fluorescence measurements were used as a new and unique method to determine the chemical composition of bi-PIBSI dispersants.

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, \(d_{lp} \approx 1 \mu m\)) to minimize their surface exposure to the oil.

Polar particles (or LPs) can cause sludge formation resulting in oil blockage and engine failure. Therefore, dispersants are added to the engine oil to minimize UFP 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.

Problems Caused by Combustion By-Products

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...

Synthesis Protocol of Succinicimide Dispersants

- Diethylenetriamine (DETA)
- Triethylenetetramine (TEPA)
- Tetraethylenepentamine (TEPA)
- Pentaethylenhexamine (PEHA)
- Hexamethylenediamine (HMDA)
- Amidino disperse (PIBSA)
- Amidino dispersed (PIBSI)

Determination of Chemical Composition

a) Fourier Transform Infrared (FTIR)

CH_1 1390 cm\(^{-1}\)
C=O 1785 cm\(^{-1}\)

b) Nuclear Magnetic Resonance (\(^1\)H NMR)

c) Gel Permeation Chromatography (GPC)

Summary of Chemical Compositions

<table>
<thead>
<tr>
<th>Dispersants</th>
<th>(^1)H NMR</th>
<th>FT-IR (Peak Height)</th>
<th>GPC</th>
<th>UV-Vis</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIBSA</td>
<td>N_H / N_H</td>
<td>1.55±2</td>
<td>1.49±1</td>
<td>1.52</td>
</tr>
<tr>
<td>b-PIBSI</td>
<td>N_H / N_H</td>
<td>1.33±2</td>
<td>1.39±2</td>
<td></td>
</tr>
<tr>
<td>m-PIBS-TEPA</td>
<td>N_H / N_H</td>
<td>1.45</td>
<td>1.55</td>
<td>1.55</td>
</tr>
</tbody>
</table>

Summary

- The chemical composition of PIBSA and PIBSI were determined.
- Fluorescence quenching of the PIBSI dispersants increases with the number of secondary amines present in the polar core. The quenching is dynamic and static in nature.
- The linear relationship found between the ratio I/I and the number of secondary amines suggests that fluorescence can be used to determine the chemical composition of PIBSI-based dispersants.

Acknowledgements:

The authors thank Imperial Oil and NSERC for funding.