Transforming Space Plastic Waste into Lubricants for Sustainable Space Missions

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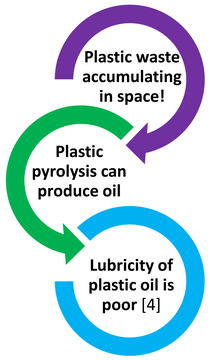
Introduction



- Today, 9000 satellites in space are orbiting the earth [1]
- 60,000 satellites will be orbiting earth by 2030 [1]
- Exploration produced 100 Trillion+ untracked pieces [1]
- Plastics created space debris alike in ocean debris [1]
- Can space plastic debris be converted into lubricants?
- Lubricity of plastic oil is poor; additives can improve it.

Friction & wear in moving mechanical components in deep space exploration can be reduced through using such upcycled plastic oils

Research Hypothesis

Ionic liquid (IL) additives can enhance the lubrication performance of plastic derived oil in space significantly

Literature Review

- On earth, plastic Market created 6300 M metric ton waste since 1930s [3]
- So far only 9% among them got recycled, 12% incinerated, 79% landfilled [3]
- Unutilized waste plastic disrupts the carbon cycle and causes pollution [3]
- Pyrolysis could be a viable technique to obtain oils from space plastic debris.

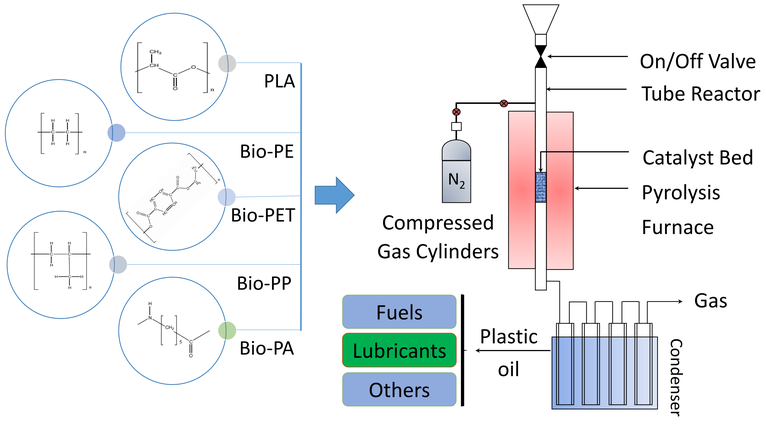
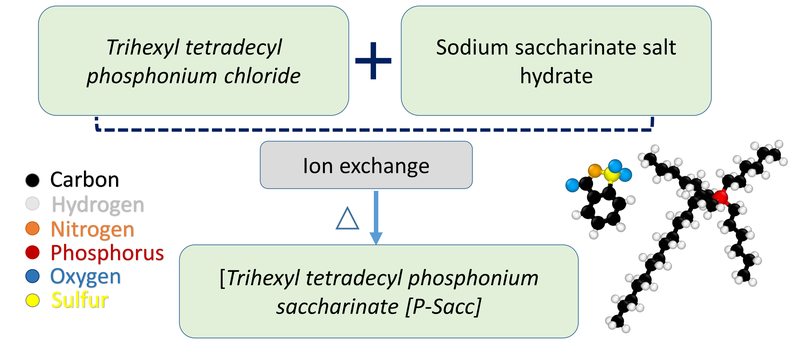


Figure 1: Process flow diagram of plastic to lubricants [4]

Plastic pyrolysis oil (PO) contains aromatics, hydrocarbons and naphtha [4]

Sugar derived saccharinate ionic liquids could be excellent additive to PO [5]

IL Synthesis & characterization



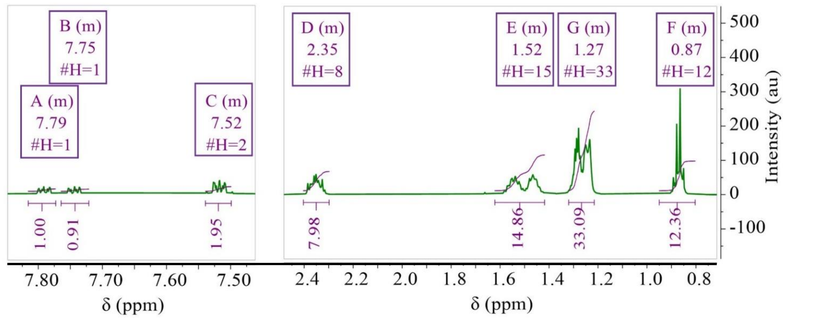


Figure 2: Structural validation of synthesized ionic liquid [P-Sacc] with ^{1}H NMR

Experimentation & Results

Experimental conditions:
Setup: Ball on disk tribometer
Tribopair: AISI 316L/Al_2O_3
Base lubricant: Plastic oil
Additive: 0-10% v/v% [P-Sacc]
Load: 40 N, Speed: 100 mm/s
Duration: 70 min, Distance: 0.42 km

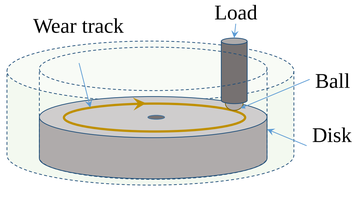


Figure 3: Experimental setup

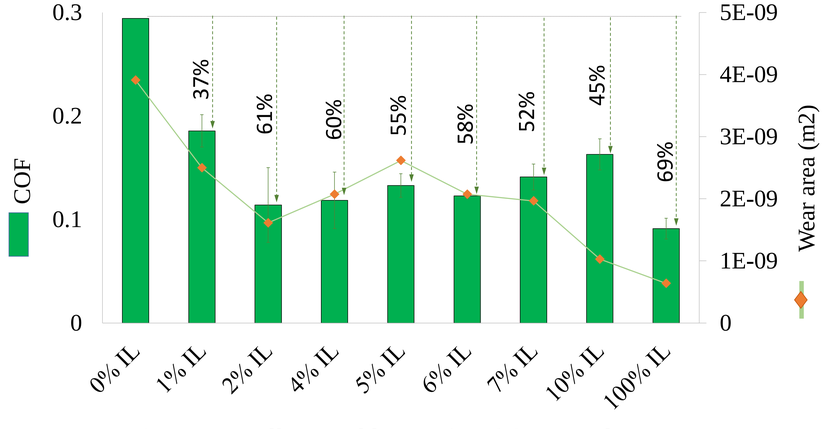
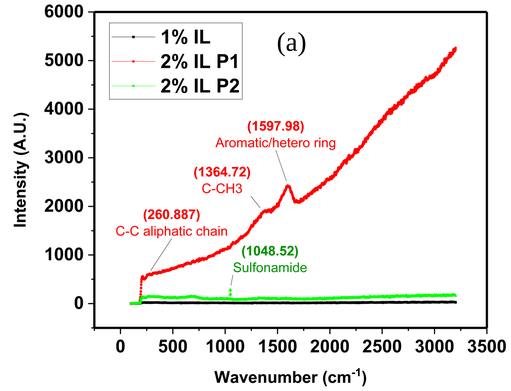
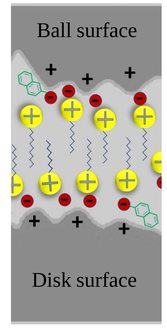


Figure 4: Coefficient of friction (COF) & wear of PO+IL

Discussion





(b)

Figure 5: (a) Raman spectroscopy, (b) Lubrication mechanism of PO+IL

Presence of aromatic groups were observed in the wear track

IL provided an adsorption layer on surface reducing COF

2% IL offered a synergistic effect and reduced COF by 61%

IL provided anti-wear effect & 2% IL reduced the wear by 60%

Summary

- ❖ Space plastic debris can be converted into oil through pyrolysis.
- ❖ Plastic oil's lubricity can be improved using saccharinate IL.
- ❖ Aromatic ring & sulfonamide group reduced COF and wear for 2% IL.

Future Scopes

- ❖ Future plastic waste in other planets can be utilized in this pathway.
- ❖ [P-Sacc] could be used as a low friction/wear additive in other oils.
- ❖ Nanoparticles could be added to further improve its performance.

Acknowledgements & References

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1. *University of Plymouth: Scientists call for global push to eliminate space junk, Science Daily, 2023*
2. *Soumya Sikdar, M H Rahman et al. (2023) Enhancement in tribological performance of plastic oil by solid lubricant additives, Lubrication science, Willey online library*
3. *Md Hafizur Rahman & P. R. Bhoi, (2021). An overview of non-biodegradable bioplastics. Journal of cleaner production, 294, 126218.*
4. *Prakash Bhoi & M. H. Rahman (2022). Hydrocarbons recovery through catalytic pyrolysis of compostable and recyclable waste plastics using a novel desk-top staged reactor. Environmental Technology & Innovation, 27, 102453.*
5. *Md Hafizur Rahman, T. Liu et. al. (2023). Physicochemical and tribological comparison of bio-and halogen-based ionic liquid lubricants. Journal of Molecular Liquids, 369, 120918.*