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FORMULATING IONIC LIQUID-BASED GREASE FOR SPACE MECHANISMS

Ionic liquids (IL) are salt composed of a cation and an anion and are liquid at room temperature. They have some beneficial features to lubricant for space mechanisms such as low volatility and stability over a wide temperature range. Further, some of them are superior to commonly used liquid lubricants for space in efficacy of additives to perfluoropolyethers (PFPE) and in better low temperature fluidity than multiply alkylated cyclopentane (MAC). By utilizing these features, an ionic liquid-based grease has been formulated aiming at the use for space mechanisms.

Selection of IL was performed in stages. First, 30 ILs were chosen out of more than 500 candidates for their non-toxicity, hydrophobicity and fluidity at -20°C. Secondly, 17 out of 30 ILs were chosen for their low volatility at high temperatures determined by themogravimetry/differential thermal analysis. In the third stage, low-temperature viscosity, surface tension and friction-and-wear characteristics in atmosphere were determined, and 7 ILs remained. With each of them, rust-preventing performance of several rust inhibitors against stainless steel was tested and, finally, a combination of an IL which had TFSA (bis[trifluoro-methylsulfonyl]amide) as the anion and a rust inhibitor which formed adsorbed film on steel surface was selected. Then several candidate greases were prepared with different thickeners and, after evaluating their consistency, bleeding and rust-preventing characteristics, a grease (IU) using aromatic polyurea as the thickener was formulated to have 60W penetration of 280.

Major properties of IU are compared with greases using PFPE and MAC as the base oil in Table 1. It shows that IU may operate at -40°C where only PFPE grease could be used.

Friction-and-wear properties of stainless steel SUS440C against itself in vacuum of 10^{-4}Pa were determined on a ball-on-disk machine lubricated with IU and the competitors under a maximum Hertzian pressure of 2.8GPa at sliding speed of 0.02m/s, Figs.1 and 2. IU displays low

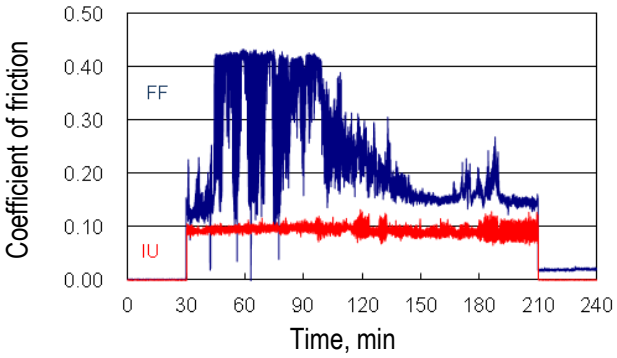

Fig.1 Coefficient of friction in vacuum

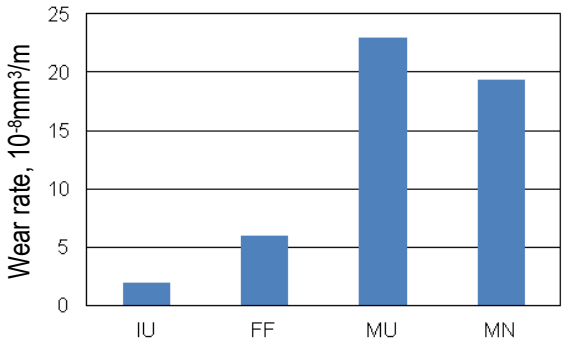

Fig.2 Wear rate in vacuum

and stable friction and causes markedly low wear rate.

Low volatility as well as low contamination by the evaporated constituents are required of the lubricants for space machinery. Total mass loss and collected volatile condensable materials were assessed, and it was confirmed that IU cleared the NASA criteria.

Table 1 Comparative properties of greases for space mechanisms

			IU	FF	MU	MN
Base oil	Type		IL	PFPE	MAC	
	Kinematic viscosity, mm²/s	40℃	20	144	104	
		–40℃	5000	5500	89000	
Thickener			Polyurea	PTFE	Polyurea	Na soap
Additives			Rust inhibitor	—	—	EP etc.
Penetration 60W			280	280	300	276

M. Hayama, "Research in application of ionic liquids to space lubricants", J. JAST, vol.58, no.12 (2013) pp.868-873 (*in Japanese*).