Can You Hear the Empty Spaces? - Improving Spacecraft Efficiency and Capability Through a Novel Microgravity Slosh Mitigation Technique

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Slosh is unwanted movement of fuel in a tank, and has caused many failed space missions. Slosh occurs during spacecraft launch and in microgravity during maneuvers. NASA and spacecraft developers have spent billions managing slosh. Baffles effectively manage launch slosh; however, mitigating slosh in microgravity, in which surface energies rule the fluid dynamics regime, requires costly subsystems that add weight and complexity. This project describes a novel method to manage microgravity slosh through custom surface energies. Acrylic tanks were treated with superhydrophobic and superhydrophilic coatings and filled at various fill fractions. The settling time for the “fuel” in coated tanks was compared to non-coated (control) tanks after an imposed acceleration. Additionally, fuel aggregation around the sump was compared between coated and non-coated tanks. Two coating profiles were investigated: 20%/80% superhydrophilic/superhydrophobic, and a 50/50 profile. The experiment was replicated for tanks with simulated propellant management devices (PMD’s). Microgravity was achieved through parabolic flight. This experiment supported the hypotheses with a significant reduction in settling time for coated tanks. The 50/50 profile performed better than the 20/80. Settling time reductions of 73% for high fill fractions and 59% for low fill fractions were achieved. The coated tanks aggregated the liquid at the sump 100% of the time, compared to 12% for the control tanks and 64% for tanks with PMDs. The results demonstrate a method to eliminate slosh subsystems, reducing cost, weight and complexity and increasing mission reliability and capacity.