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The Full MoS_2 Monty...Temperature!

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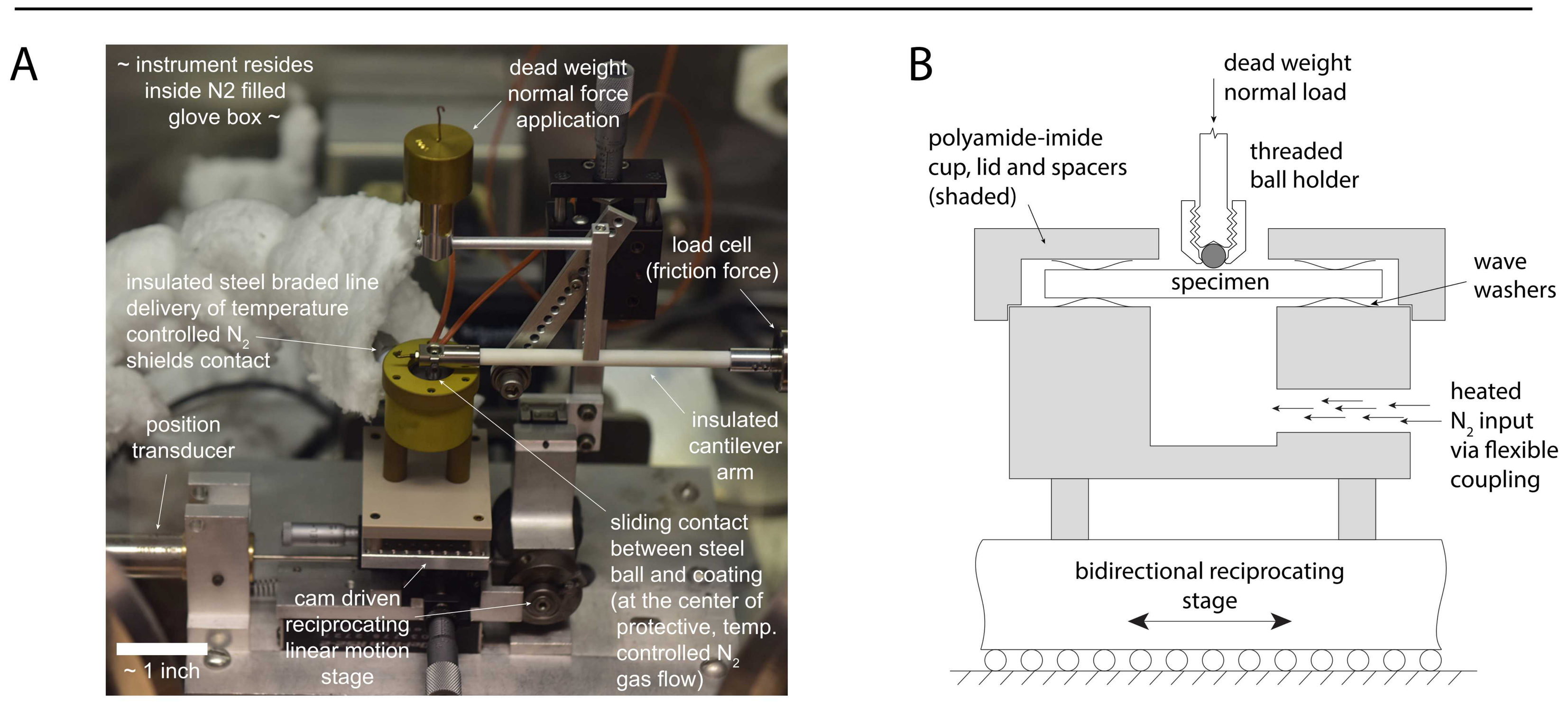
Introduction

Everybody knows MoS_2. Consensus in the literature however, has not been reached on how MoS_2 performs at extreme temperatures due to the nature of difficulty for extreme temperature tesing. Performance at the extremes is crucial for aerospace applications. This poster presents a tribometer capable of making measurements at extreme temperatures. Using variable temperature friction tests, it can be seen that MoS_2 has low friction throughout extreme temperatures and has a thermal to athermal transition in friction behaviour and wear at room temperature.

Variable Temperature Tests



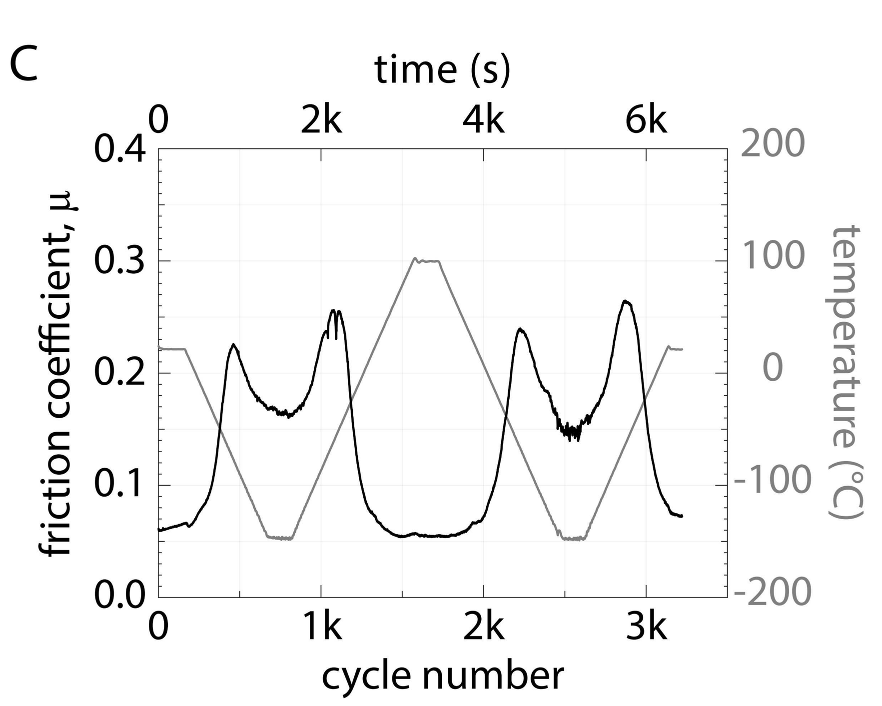


Fig. 1. (A) Annotated picture of the high temp-cryo tribometer. (B) Diagram of PAI flowcell (C) Typical trace of friction and temperature vs. cycles

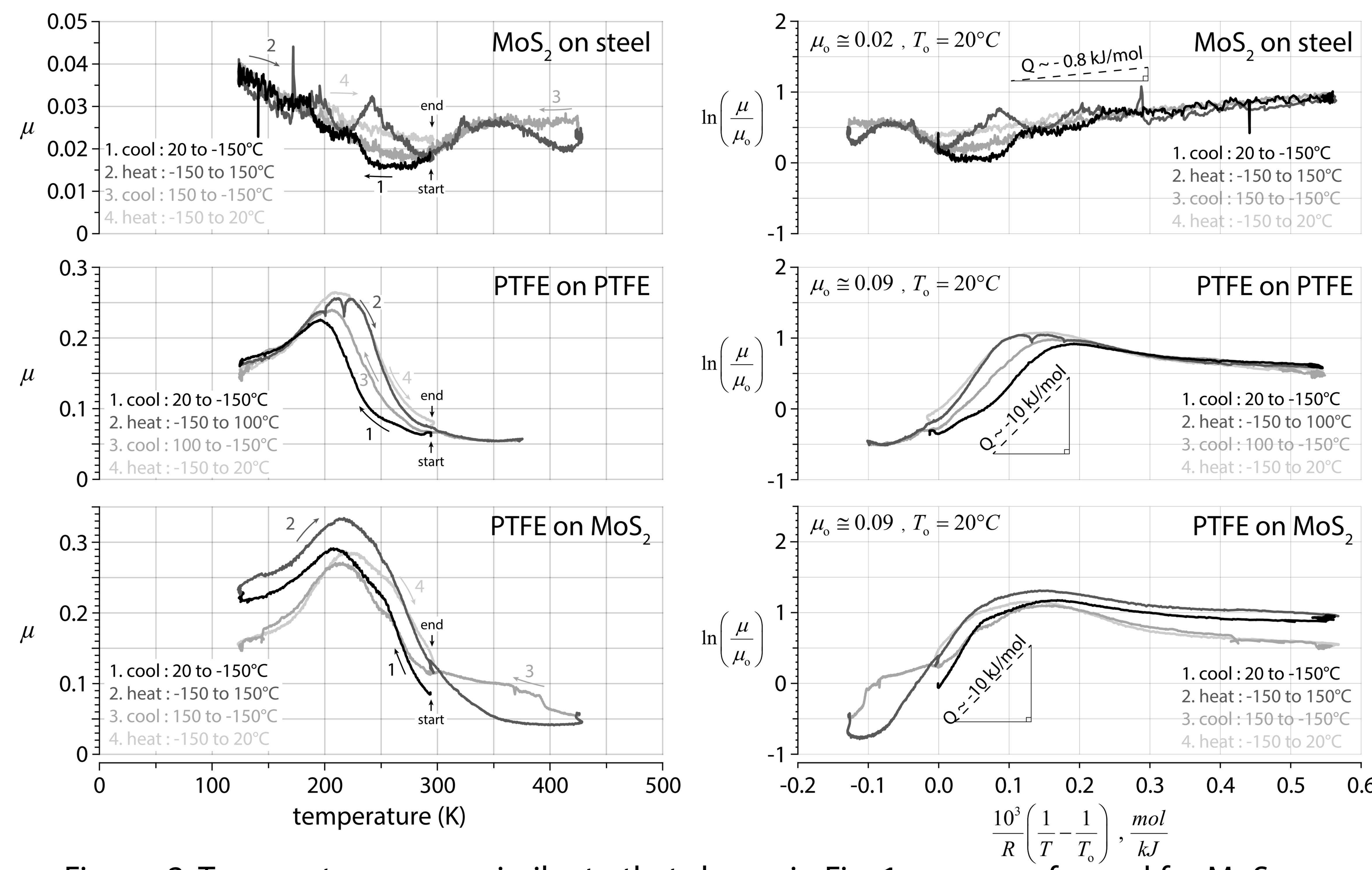


Figure. 2: Temperature ramps similar to that shown in Fig. 1c were performed for MoS_2 on Steel, PTFE on PTFE and PTFE on MoS_2. The left column shows friction vs. temperature plots for each of the three tests. The right column shows the same data plotted in Arrhenius form with normalized friction and temperature

For MoS2 on Steel, weak thermal friction behaviour can be seen with an activation energy of Q~-0.8 kJ/mol. A transition in friction behaviour to athermal is seen around 20 °C. Self-mated PTFE was run to calibrate the tester. Three distinct friction transitions can be seen at -100 °C, 20 °C and 116 °C correlating to mobility changes in the amorphous and crystalline regions of the PTFE. A PTFE ball was run on MoS2, the similarity in friction behaviour to self-mated PTFE corroborates the hypothesis that near-surface deformation of the lower shear strength material accomodates sliding.

Temperature Dependent Wear of MoS_2

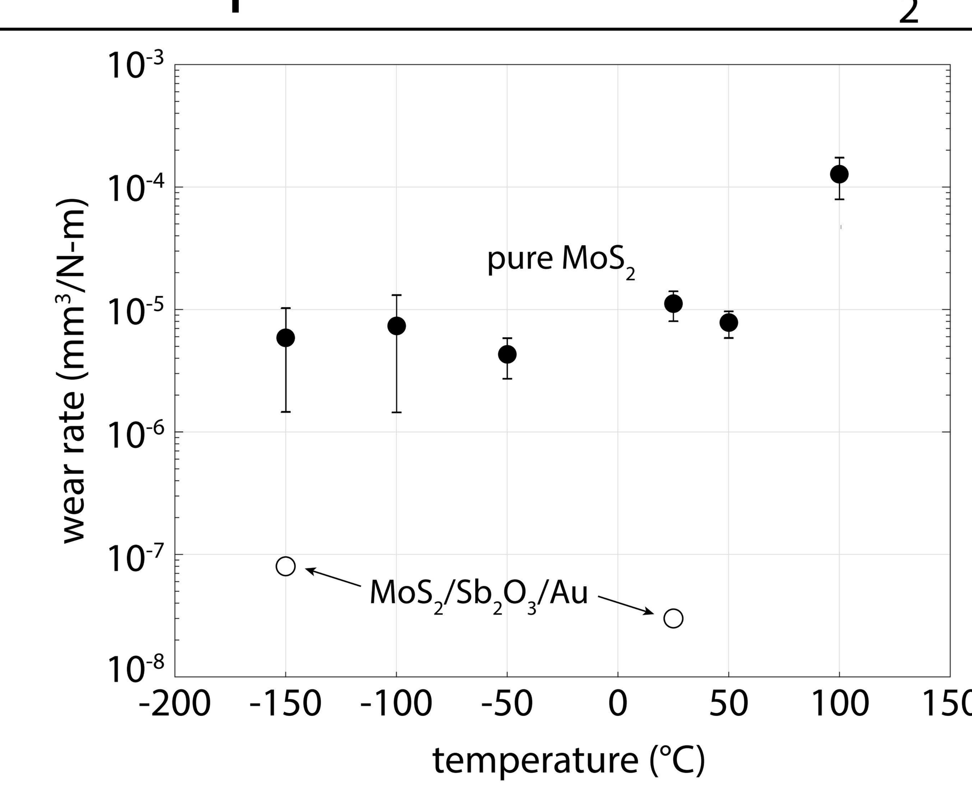


Figure. 3: Wear Rates for Pure MoS_2 and Composite MoS_2 for temperatures between -150 °C and 100 °C.

The wear of pure MoS_2 transitions from thermal to athermal behaviour at approximately 50 °C. This temperature is approximately kT for pure MoS_2. We hypothesize that at temperatures above kT, the increased phonon energy inhibits the lasting formation of long-range ordered sheets of MoS_2 leading to increased wear and friction.

Arrhenius, Amontonian, or Neither?

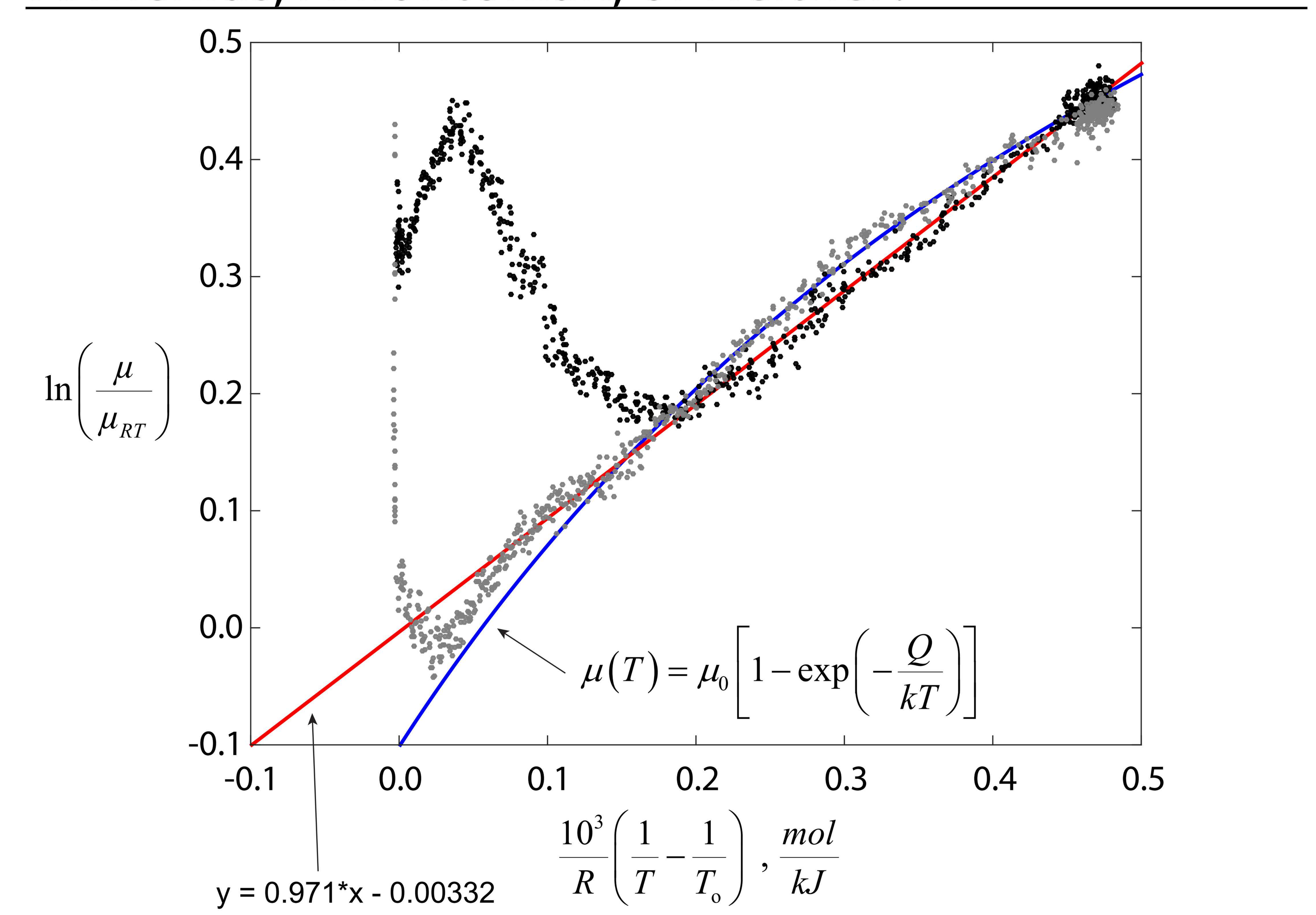


Figure. 4: Temperature ramp similar to Fig. 1c performed for MoS_2 on Steel. An Arrhenius plot of normalized friction and temperature is shown.

The curvature in fig. 4 implies that MoS_2 does not follow Arrhenius behavior nor Amontonian. We hypothesize that the curvature is representative of a change in the fundamental shear strength of MoS_2. The shear strength of MoS_2 is a function of temperature, defect density and commensurability.

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