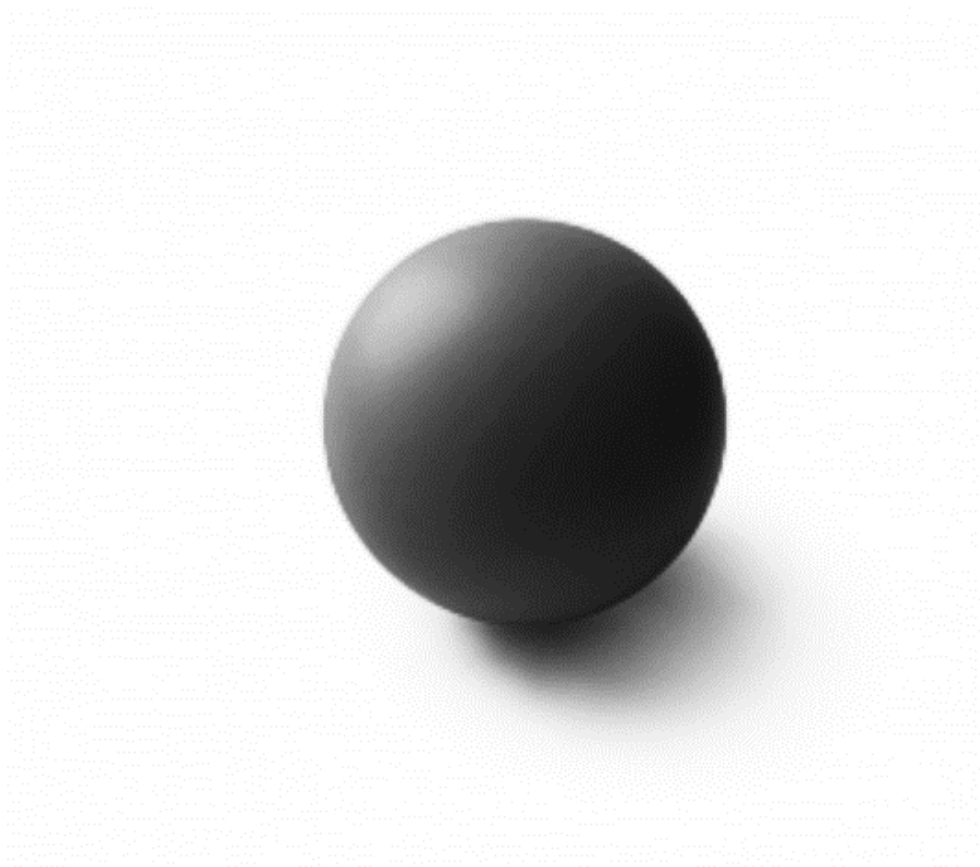


**RUBBER FRICTION EVALUATION AT EXTREME LOW SPEEDS
USING TRIBOMETER**



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INTRO

Friction is the force that resists the relative motion of solid surfaces sliding against each other. When the relative motion of these two contact surfaces takes place, the friction at the interface converts the kinetic energy into heat. Such a process can also lead to wear of the material and thus performance degradation of the parts in use.

With a large stretch ratio, high resilience, as well as great waterproof properties and wear resistance, rubber is extensively applied in a variety of applications and products in which friction plays an important role, such as automobile tires, windshield wiper blades, shoe soles and many others. Depending on the nature and requirement of these applications, either high or low friction against different materials is desired. As a consequence, a controlled and reliable measurement of friction of rubber against various surfaces becomes critical.

MEASUREMENT OBJECTIVE

The coefficient of friction, COF, of rubber against different materials is measured in a controlled and monitored manner using the Nanovea Tribometer. In this study, we would like to showcase the capacity of Nanovea Tribometer for measuring the COF of different materials at extremely low speeds.

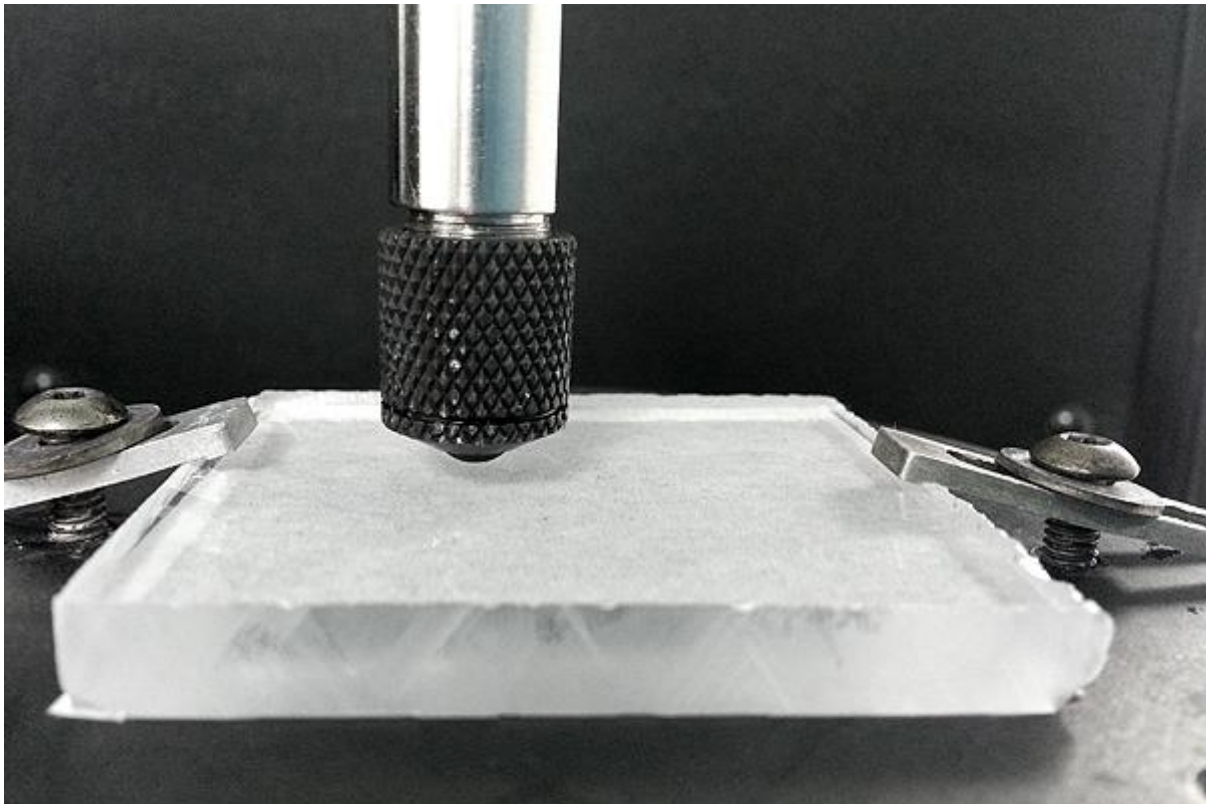


Fig. 1: Pin-on-disc test setup for COF evaluation.

MEASUREMENT PRINCIPLE

TRIBOMETER PRINCIPLE

The sample is mounted on a rotating stage, while a known force is applied on a pin, or ball, in contact with the sample surface to create the wear. The pin-on-disk test is generally used as a comparative test to study the tribological properties of the materials. The, coefficient of friction, COF, is recorded in situ. The volume lost allows calculating the wear rate of the material. Since the action performed on all samples is identical, the wear rate can be used as a quantitative comparative value for wear resistance.

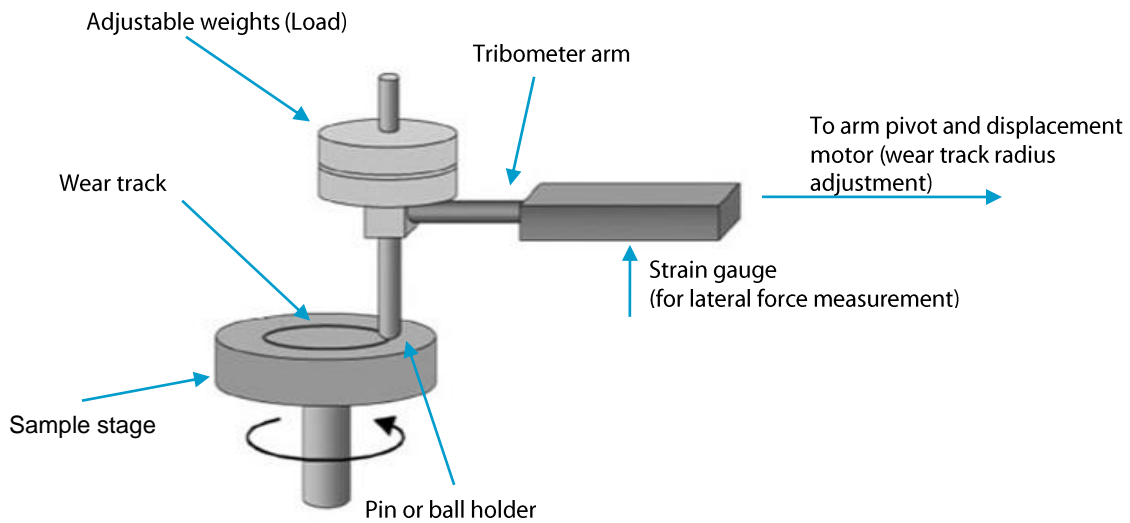


Fig. 2: Schematic of the pin-on-disk test.

TEST PROCEDURE

The coefficient of friction, COF, of rubber balls (6 mm dia., RubberMill) on three materials (Stainless steel SS 316, Cu 110 and optical Acrylic) was evaluated by Nanovea Tribometer. The tested metal samples were mechanically polished to mirror-like surface finish prior to the measurement. The slight deformation of the rubber ball under the applied normal load created an area contact, which also helps to reduce the impact of asperities or inhomogeneity of sample surface finish to the COF measurements. The test parameters are summarized in Table 1.

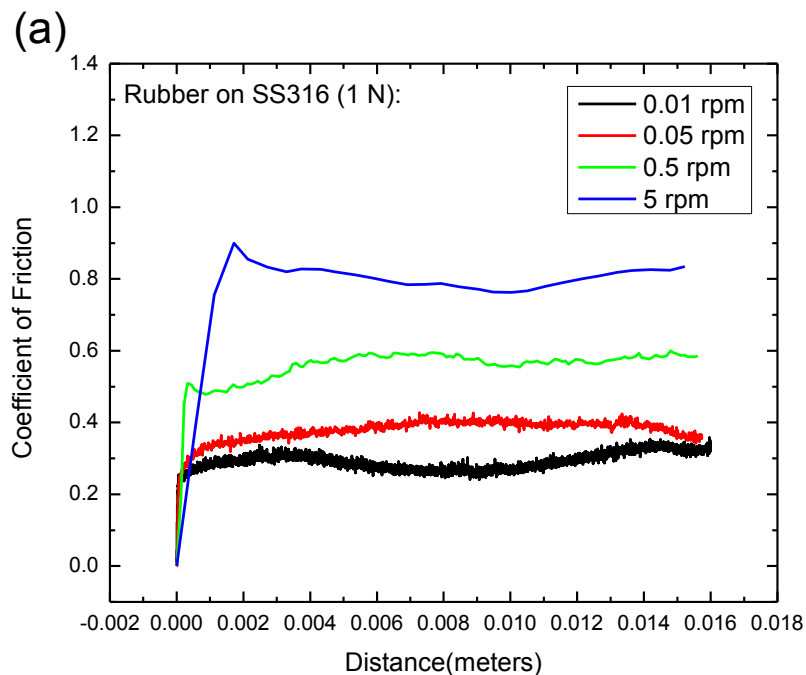
Test parameters	Value
Normal force	1 N
Speed	0.01, 0.05, 0.5 and 5 rpm
Duration of test	0.25 Revolution

Table 1: Test parameters of the COF measurement.

RESULTS AND DISCUSSION

The COFs of rubber ball against different materials at four different speeds are shown in Fig. 4, and the average COFs calculated automatically by the software are summarized and compared in Fig. 5. It is interesting that the metal samples (SS 316 and Cu 110) exhibit significantly increased COFs as the rotational speed increases from a very low value of 0.01 rpm to 5 rpm – the COF value of the rubber/SS 316 couple increases from 0.29 to 0.8, and from 0.65 to 1.1 for the rubber/Cu 110 couple. This finding is in agreement with the results reported from several laboratories¹²³. As proposed by Grosch⁴, the friction of rubber is mainly determined by two mechanisms: (1) the adhesion between rubber and the other material, and (2) the energy losses due to the deformation of the rubber caused by surface asperities. Schallamach⁵ observed waves of detachment of rubber from the counter material across the interface between soft rubber spheres and a hard surface. The force for rubber to peel from the substrate surface and rate of waves of detachment can explain the different friction at different speeds during the test.

In comparison, the rubber/acrylic material couple exhibits high COFs at different rotational speeds. The COF value slightly increases from ~1.02 to ~1.09 as the rotational speed increases from 0.01 rpm to 5 rpm. Such high COF is possibly attributed to stronger local chemical bonding at the contact face formed during the tests.



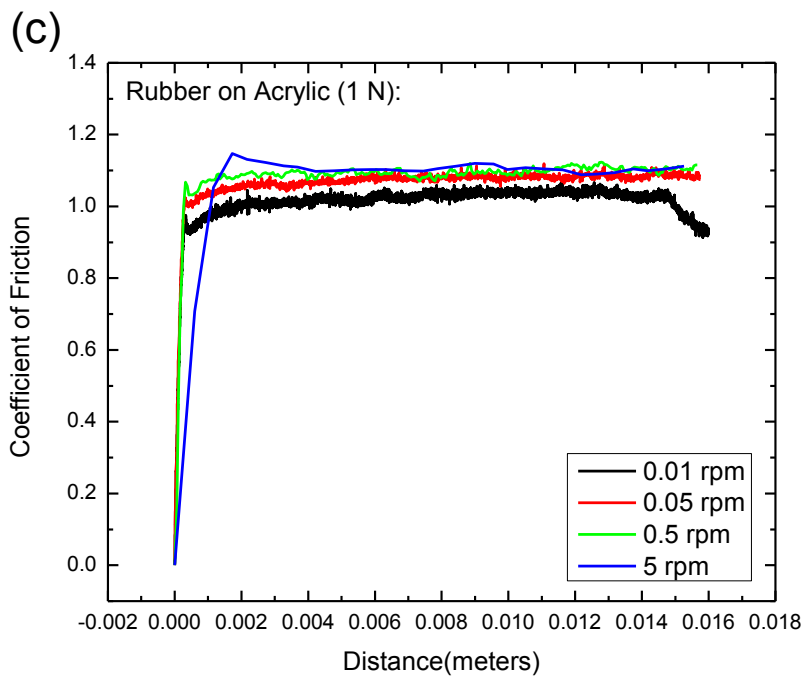
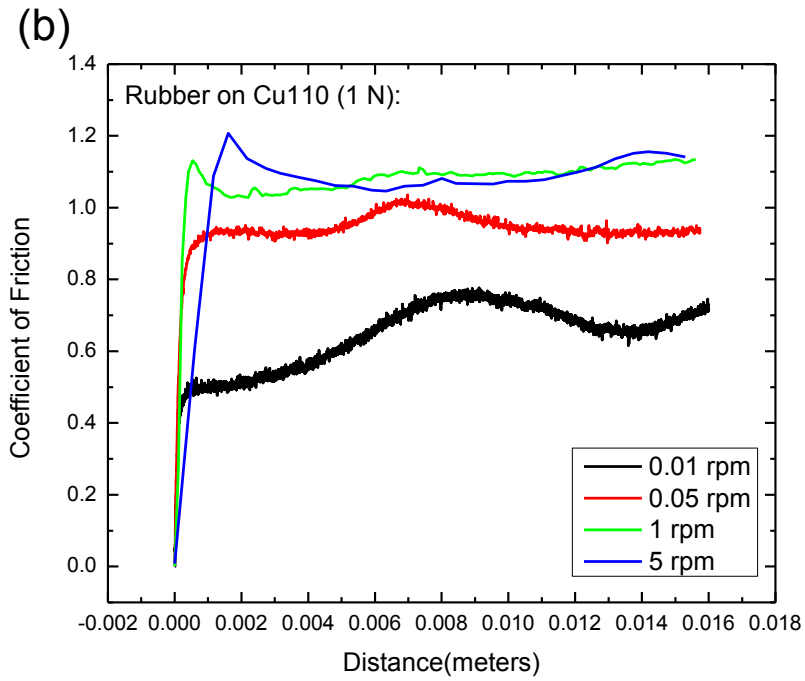


Fig. 4: Coefficient of friction of rubber ball against (a) SS 316, (b) Cu 110, (c) Acrylic.

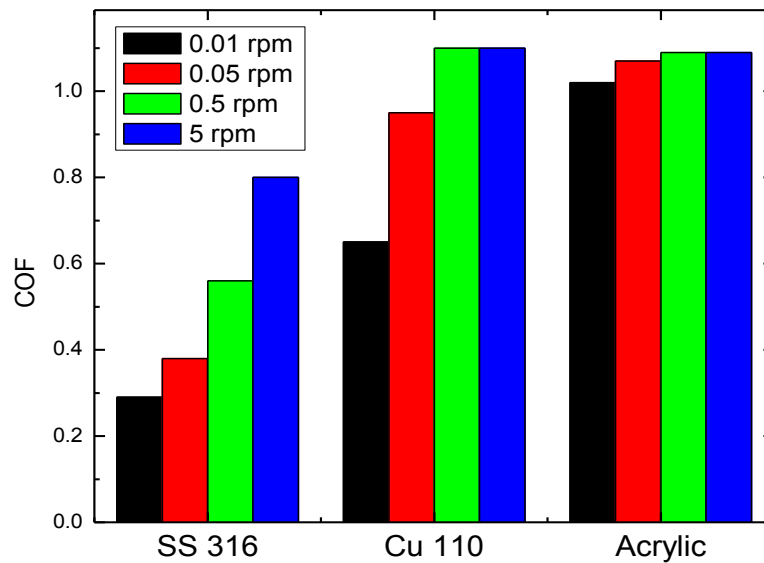


Fig. 5: Comparison of COF of rubber against different material couples at different speeds.

CONCLUSION

In this study, we show that at extremely low speeds, the rubber exhibits a peculiar frictional behavior – its friction against a hard surface increases with the increased speed of the relative movement. Rubber shows different friction when it slides on different materials. Nanovea Tribometer can evaluate the frictional properties of materials in a controlled and monitored manner at different speeds, allowing users to improve fundamental understanding of the friction mechanism of the materials and select the best material couple for targeted tribological engineering applications.

Nanovea Tribometer offers precise and repeatable wear and friction testing using ISO and ASTM compliant rotative and linear modes, with optional high temperature wear, lubrication and tribo-corrosion modules available in one pre-integrated system. It is capable of controlling the rotational stage at extremely low speeds down to 0.0003 rpm and monitor the evolution of friction in situ. Nanovea's unmatched range is an ideal solution for determining the full range of tribological properties of thin or thick, soft or hard coatings, films and substrates.

Learn More about the [Nanovea Tribometer](#)

¹ Thirion P 1946 Reu. Gen. Caoutchouc 23 101-6

² Schallamach A 1952 Proc. Phys. Soc. B 65 657-61

³ Roth F L, Driscoll R L and Holt W L 1942 J. Res. Nut1 Bur. Std USA 28 439-62

⁴ Grosch K A 1963 Proc. R. Soc. A 274 21-39

⁵ Schallamach A 1971 Wear 17 301-12