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TRIBOLOGY OF POLYMERS

USING

THE NANOVEA T2000

Prepared by

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Introduction

Polymers have been extensively used in a wide variety of applications and have become an indispensable part of everyday life. Natural polymers such as amber, silk, and natural rubber have played an essential role in human history. The fabrication process of synthetic polymers can be optimized to achieve unique physical properties such as toughness, viscoelasticity, self-lubrication, and many others.

Importance of Wear and Friction of Polymers

Polymers are commonly used for tribological applications, such as tires, bearings, and conveyor belts. Different wear mechanisms occur depending on the mechanical properties of the polymer, the contact conditions, and the properties of the debris or transfer film formed during the wear process. To ensure that the polymers possess sufficient wear resistance under the service conditions, reliable and quantifiable tribological evaluation is necessary. Tribological evaluation allows us to quantitatively compare the wear behaviors of different polymers in a controlled and monitored manner to select the material candidate for the target application.

The Nanovea Tribometer offers repeatable wear and friction testing using ISO and ASTM compliant rotative and linear modes, with optional high-temperature wear and lubrication modules available in one pre-integrated system. This unmatched range allows users to simulate the different work environments of the polymers including concentrated stress, wear, and high temperature, etc.

MEASUREMENT OBJECTIVE

In this study, we showcased that the Nanovea Tribometer is an ideal tool for comparing the friction and wear resistance of different polymers in a well-controlled and quantitative manner.

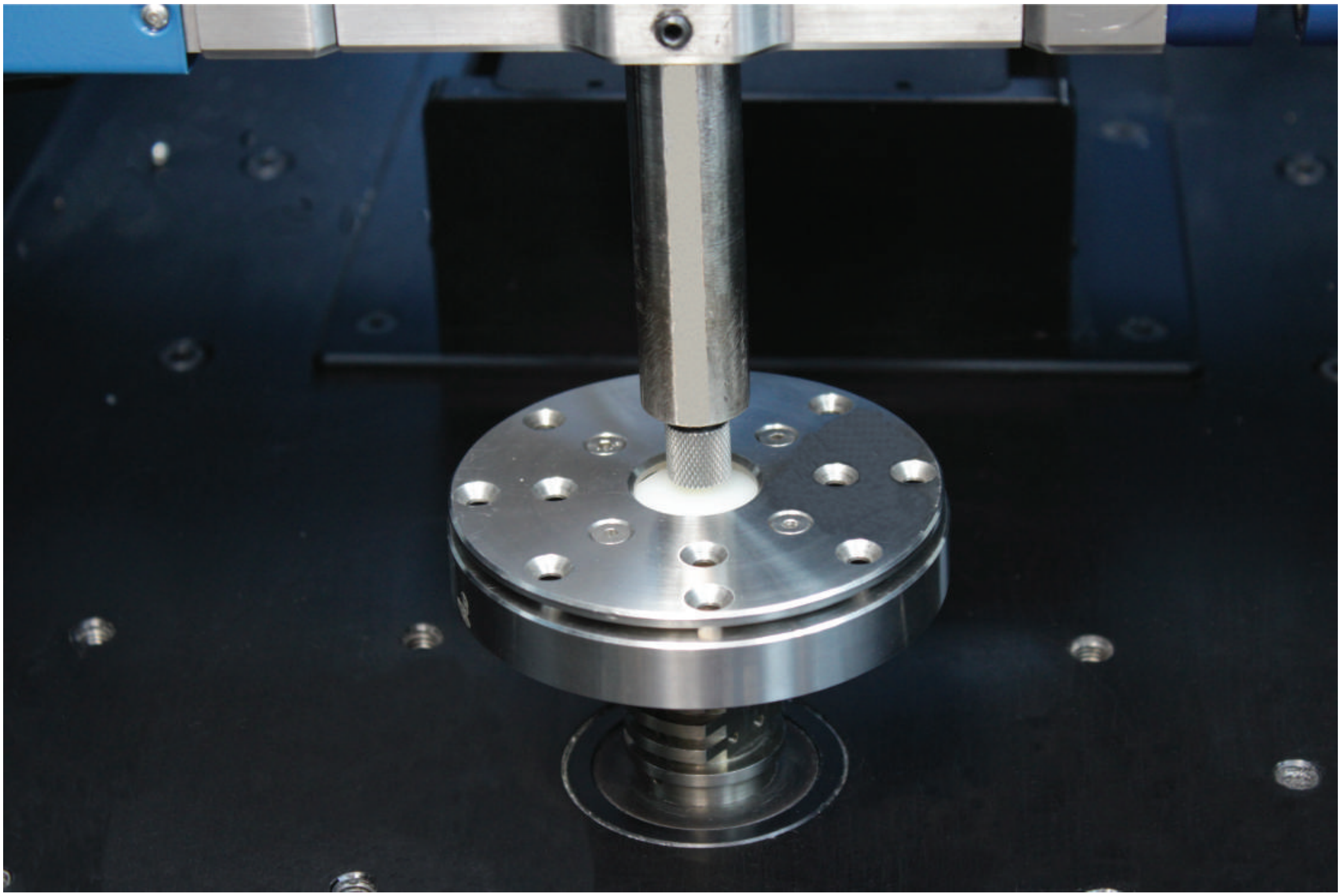


Figure 1: Setup of the polymer wear test.

TEST PROCEDURE

The coefficient of friction (COF) and the wear resistance of different common polymers were evaluated by the Nanovea Tribometer. An Al_2O_3 ball was used as the counter material (pin, static sample). The wear tracks on the polymers (dynamic rotating samples) were measured using a non-contact 3D profilometer and optical microscope after the tests concluded. It should be noted that a non-contact endoscopic sensor can be used to measure the depth the pin penetrates the dynamic sample during a wear test as an option. The test parameters are summarized in Table 1. The wear rate, K, was evaluated using the formula K=Vl(Fxs), where V is the worn volume, F is the normal load, and s is the sliding distance.

Please note that Al_2O_3 balls were used as the counter material in this study. Any solid material can be substituted to more closely simulate the performance of two specimens under actual application conditions.

Test parameters	Value
Ball material	Al_2O_3
Ball diameter	6mm
Normal force	20 N
Rotational speed	200 RPM
Duration of test	10 min
Wear track radius	5mm
Lubricant	None
Atmosphere	Air
Temperature	24°C (room)

Table 1: Test parameters of the wear measurements.

Sample of Nylon 66.

RESULTS AND DISCUSSION

Wear rate is a vital factor for determining the service lifetime of the materials, while the friction plays a critical role during the tribological applications. **Figure 2** compares the evolution of the COF for different polymers against the Al_2O_3 ball during the wear tests. COF works as an indicator of when failures occur and the wear process enters a new stage. Among the tested polymers, HDPE maintains the lowest constant COF of ~0.15 throughout the wear test. The smooth COF implies that a stable tribo-contact is formed.

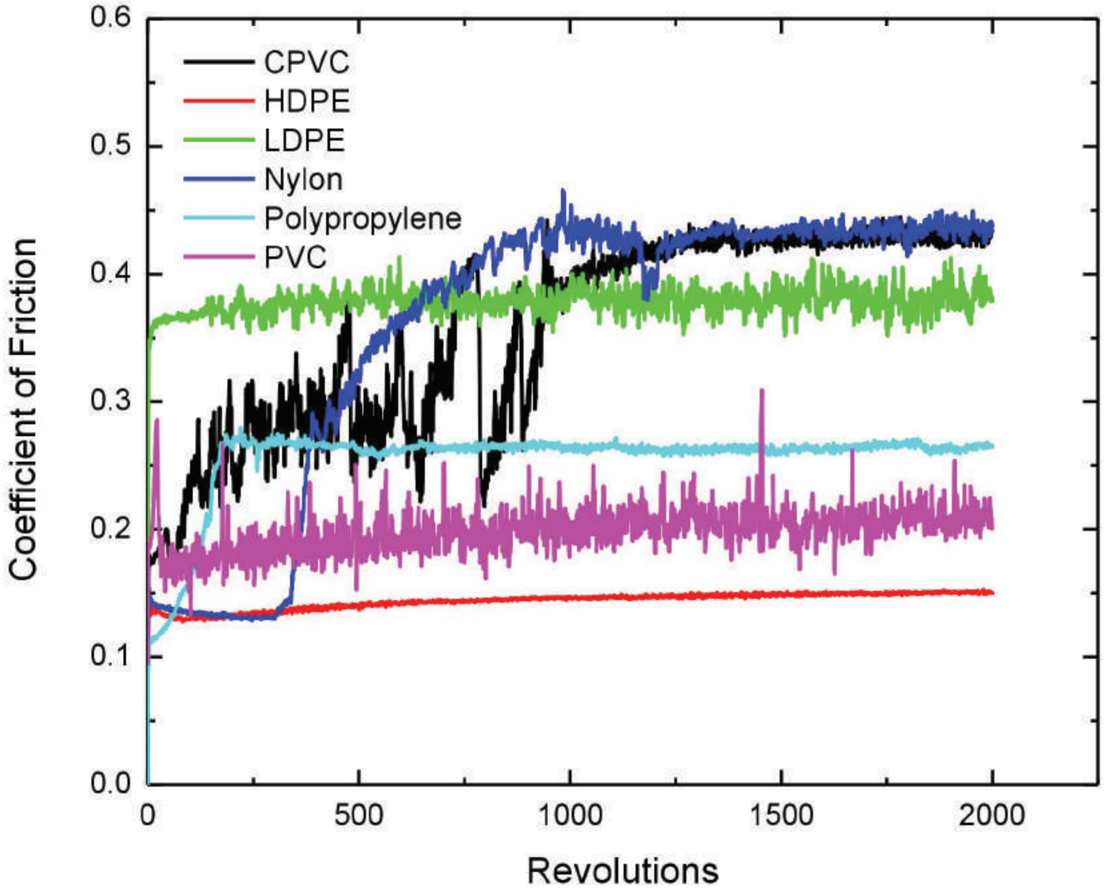
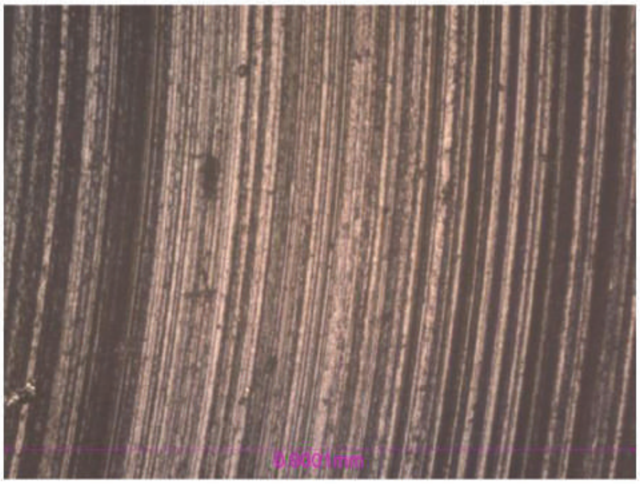


Figure 2: Evolution of COF during the wear tests.

Figure 3 and **Figure 4** compare the wear tracks of the polymer samples after the test is measured by the optical microscope. The In-situ non-contact 3D profilometer precisely determines the wear volume of the polymer samples, making it possible to accurately calculate wear rates of 0.0029, 0.0020, and 0.0032m^3/N m, respec- tively. In comparison, the CPVC sample shows the highest wear rate of 0.1121m^3/N m. Deep parallel wear scars are present in the wear track of CPVC.

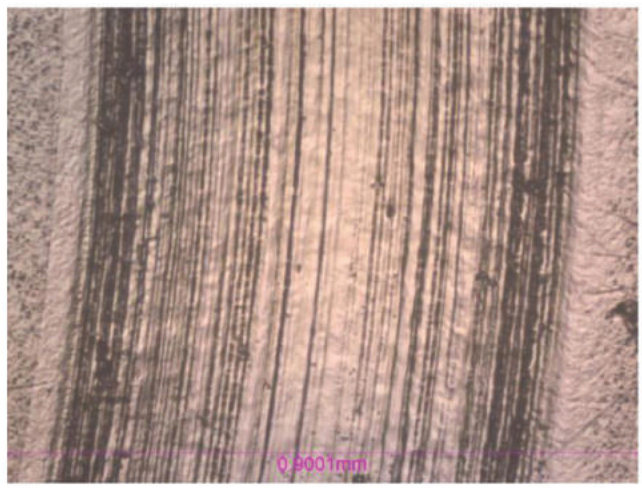
CPVC:



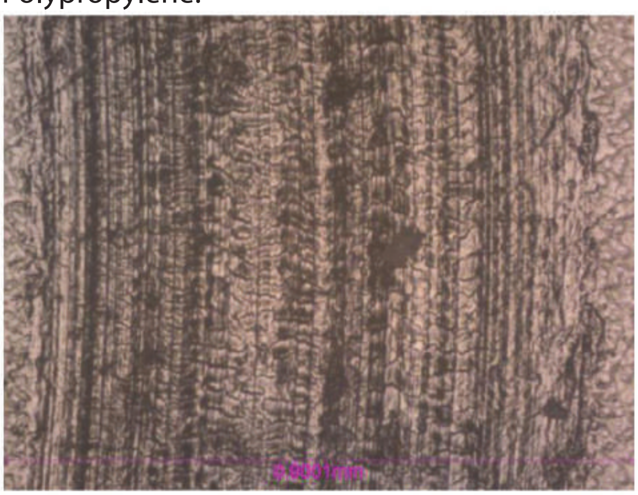
HDPE:

LDPE:

Nylon 66:



Polypropylene:



PVC:

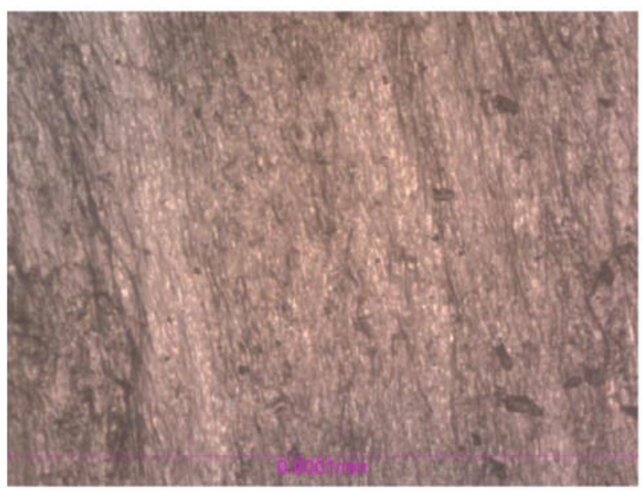


Figure 3: Wear scars on the polymer samples after the tests.

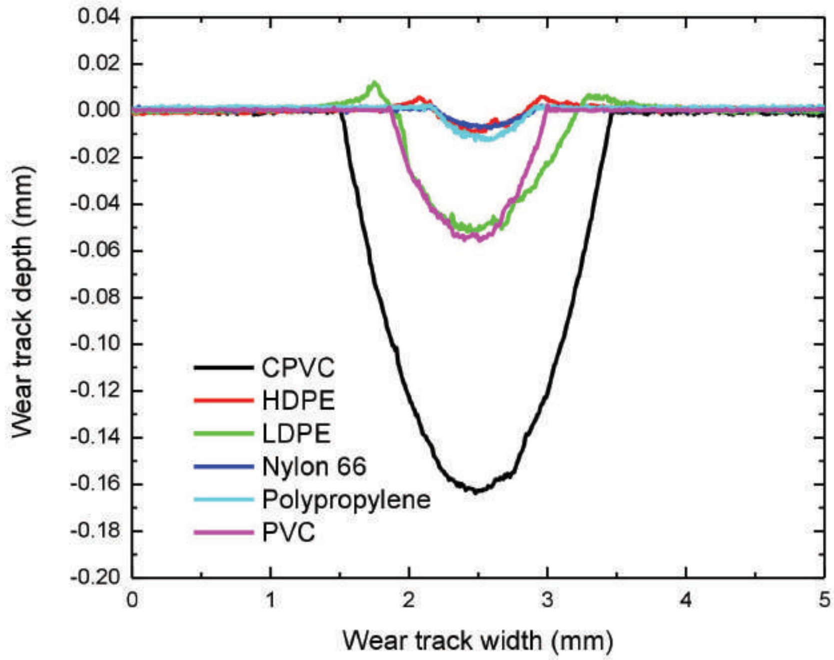


Figure 4: Profiles of the wear track cross section.

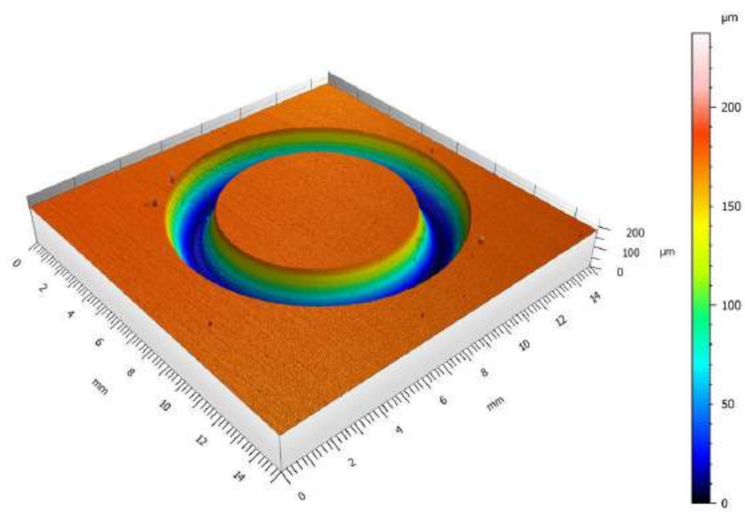


Figure 5: 3D morphology of the wear track on the CPVC sample.

Polymer	Maximum depth µm	Wear rate mm^3/N m
CPVC	167	0.1121
HOPE	12.1	0.0029
LOPE	62.2	0.0296
Nylon 66	8.87	0.0020
Polypropylene	14.2	0.0032
PVC	59.2	0.0214

Table 2: Wear track depth and wear rate analysis of the polymers.

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Conclusion

The wear resistance of the polymers plays a vital role in their service performance. In this study, we showcased that the Nanovea Tribometer evaluates the coefficient of friction and wear rate of different polymers in a well-controlled and quantitative manner. HDPE shows the lowest COF of ~0.15 among the tested polymers. HDPE, Nylon 66, and Polypropylene samples possess low wear rates of 0.0029, 0.0020 and 0.0032 m^3/N m, respec- tively. The combination of low friction and great wear resistance makes HDPE a good candidate for polymer tribological applications.

The In-situ non-contact 3D profilometer enables precise wear volume measurement and offers a tool to analyze the detailed morphology of the wear tracks, providing more insight into the fundamental understanding of wear mechanisms

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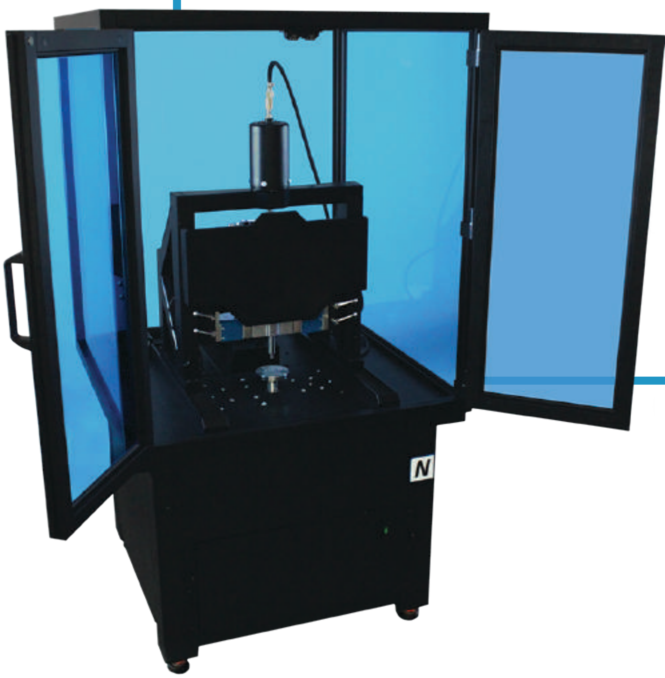
T2000
Tribometer



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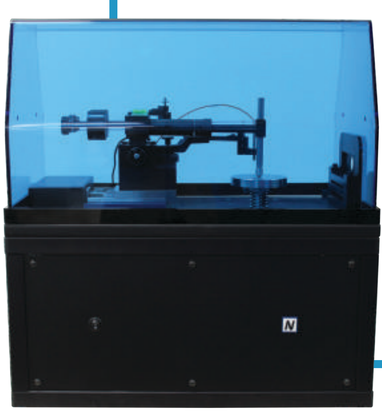

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