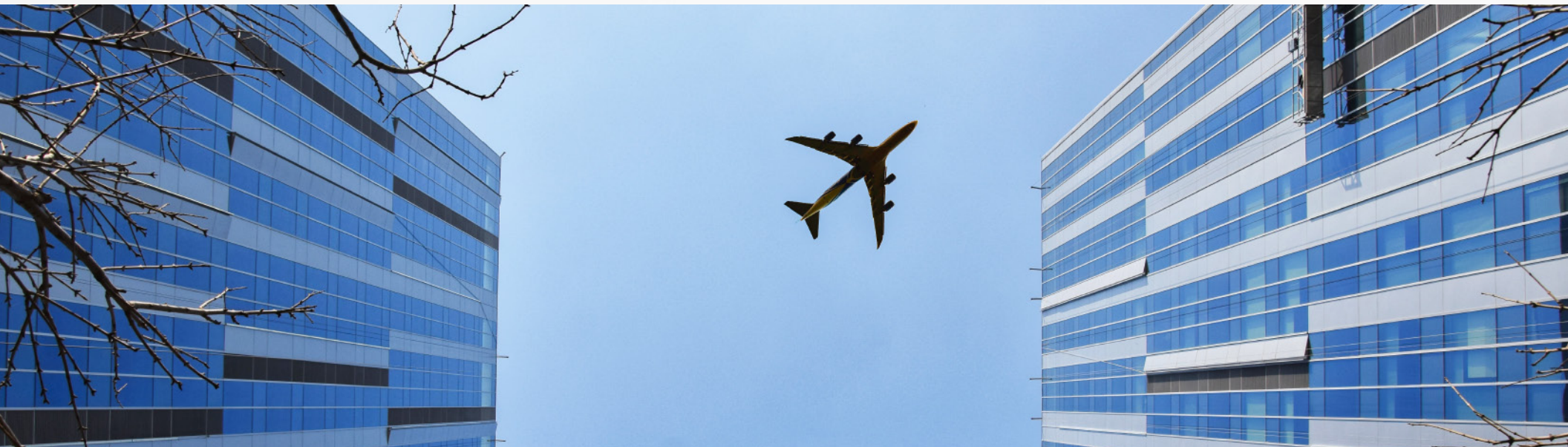# GLASS COATING HUMIDITY

WEAR TESTING BY TRIBOMETER

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INTRODUCTION

Self-cleaning glass coating creates an easy-clean glass surface that prevents buildup of grime, dirt and staining. Its self-cleaning feature significantly reduces the frequency, time, energy and cost on cleaning, making it an attractive choice for a variety of residential and commercial applications, such as glass facade, mirrors, shower glasses, windows and windshields.

IMPORTANCE OF WEAR RESISTANCE OF SELF-CLEANING GLASS COATING

A major application of the self-cleaning coating is the exterior surface of the glass facade on skyscrapers. The glass surface is often attacked by high-speed particles carried by strong winds. The weather condition also plays a major role in the service lifetime of the glass coating. It can be very difficult and costly to surface treat the glass and apply the new coating when the old one fails. Therefore, the wear resistance of the glass coating under different weather condition is critical.

In order to simulate the realistic environmental conditions of the self-cleaning coating in different weather, repeatable wear evaluation in a controlled and monitored humidity is needed. It allows users to properly compare the wear resistance of the self-cleaning coatings exposed to different humidity and to select the best candidate for the targeted application.

MEASUREMENT OBJECTIVE

In this study, we showcased that the **NANOVEA** T100 Tribometer equipped with a humidity controller is an ideal tool for investigating the wear resistance of self-cleaning glass coatings in different humidity.

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NANOVEA

T100
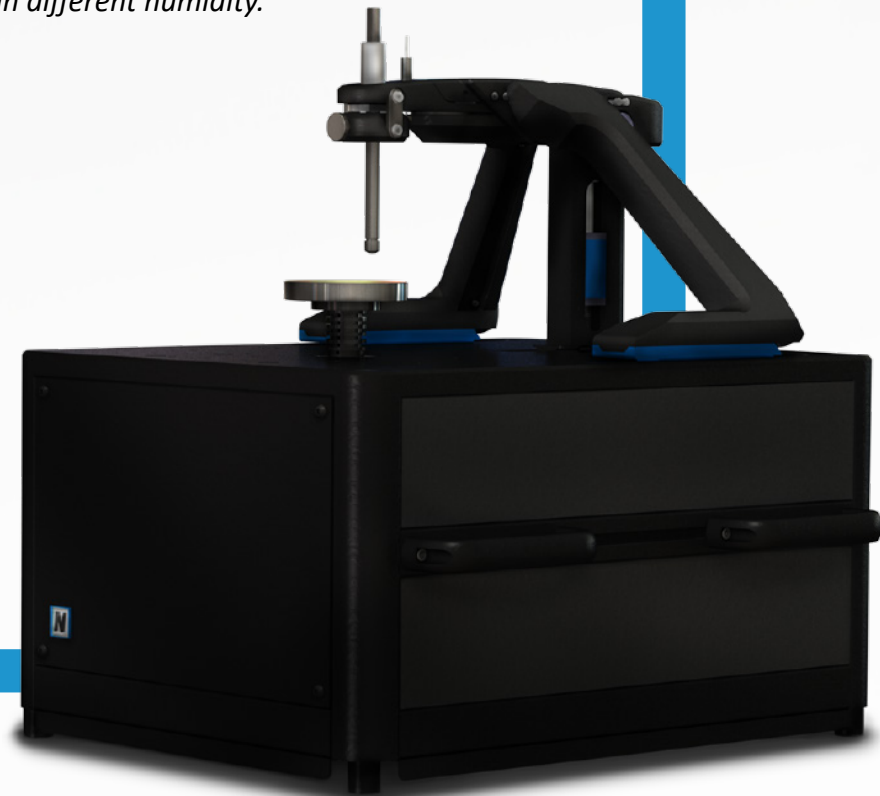
TEST PROCEDURES

The soda lime glass microscope slides were coated with self-clean glass coatings with two different treatment recipes. These two coatings are identified as Coating 1 and Coating 2. An uncoated bare glass slide is also tested for comparison.

NANOVEA Tribometer equipped with a humidity control module was used to evaluate the tribological behavior, e.g. coefficient of friction, COF, and wear resistance of the self-clean glass coatings. A WC ball tip (6 mm dia.) was applied against the tested samples. The COF was recorded in situ. The humidity controller attached to the tribo-chamber precisely controlled the relative humidity (RH) value in the range of ±1 %. The wear track morphology was examined under the optical microscope after the wear tests.

TEST PARAMETERS
of the Pin-on-Disk measurement in different humidity.

NORMAL FORCE .... **1 N**
ROTATIONAL SPEED .... **60 rpm**
TEST DURATION .... **5 min**
ATMOSPHERE .... **Air**
TEMPERATURE .... **24°C (room)**
WEAR TRACK RADIUS .... **5 mm**
RELATIVE HUMIDITY **30%, 60%, 90%**
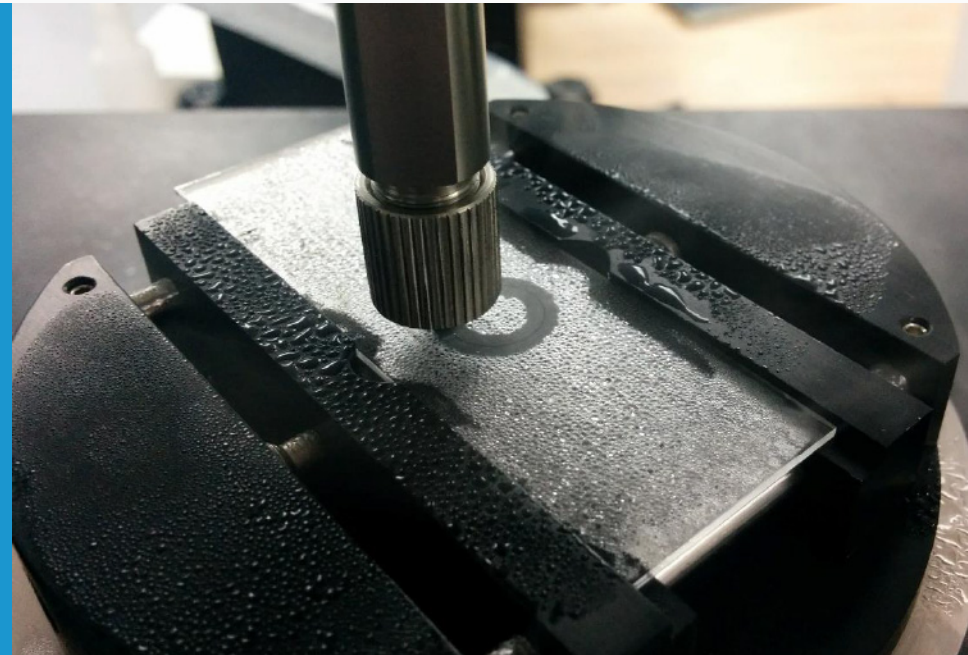
RESULTS & DISCUSSION

The pin-on-disk wear tests in different humidity conditions were conducted on the coated and uncoated glass samples. The COF was recorded in situ during the wear tests as shown in **FIGURE 1** and the average COF is summarized in **FIGURE 2**. **FIGURE 4** compares the wear tracks after the wear tests.

As shown in **FIGURE 1**, the uncoated glass exhibits a high COF of ~0.45 once the sliding movement begins in the 30% RH, and it progressively increases to ~0.6 at the end of the 300-revolution wear test. In comparison, the coated glass samples Coating 1 and Coating 2 show a low COF below 0.2 at the beginning of the test. The COF of Coating 2 stabilizes at ~0.25 during the rest of the test, while Coating 1 exhibits a sharp increase of COF at ~250 revolutions and the COF reaches a value of ~0.5. When the wear tests are carried out in the 60% RH, the uncoated glass still shows a higher COF of ~0.45 throughout the wear test. Coatings 1 and 2 exhibit the COF values of 0.27 and 0.22, respectively. In the 90% RH, the uncoated glass possesses a high COF of ~0.5 at the end of the wear test. Coatings 1 and 2 exhibit comparable COF of ~0.1 as the wear test starts. Coating 1 maintains a relatively stable COF of ~0.15. Coating 2, however, fails at ~100 revolutions, followed by a significant increase of COF to ~0.5 towards the end of the wear test.

The low friction of the self-clean glass coating is caused by its low surface energy. It creates a very high static water contact angle and low roll-off angle. It leads to formation of small water droplets on the coating surface in the 90% RH as shown under the microscope in **FIGURE 3**. It also results in decrease of the average COF from ~0.23 to ~0.15 for Coating 2 as the RH value increases from 30% to 90%.
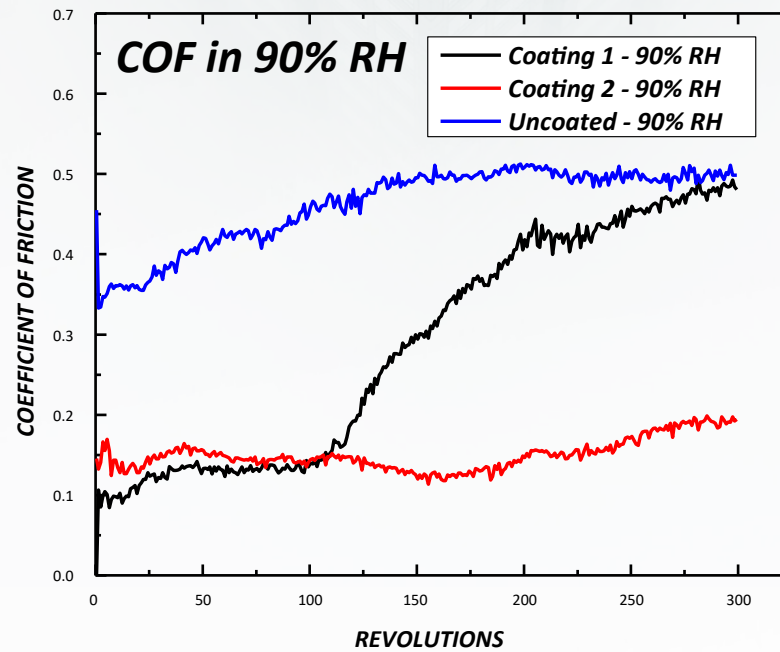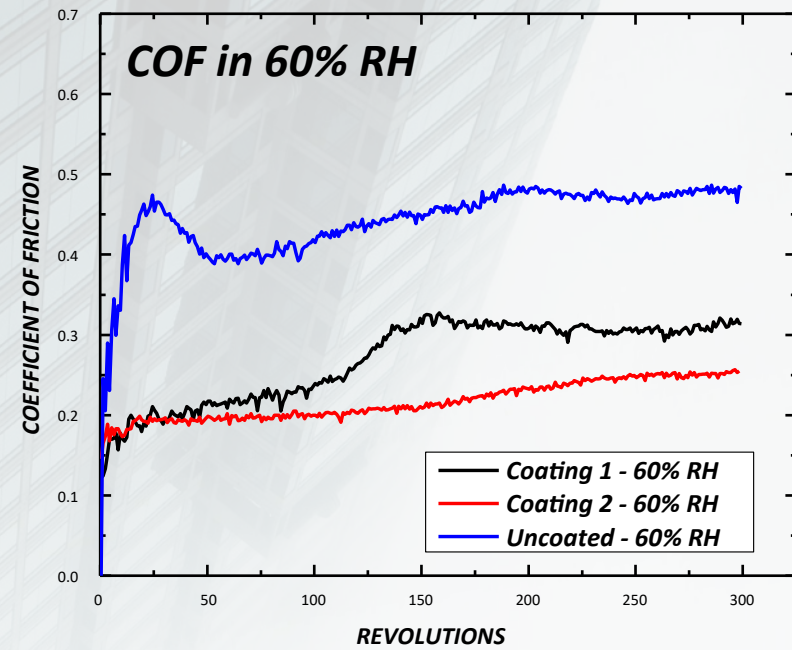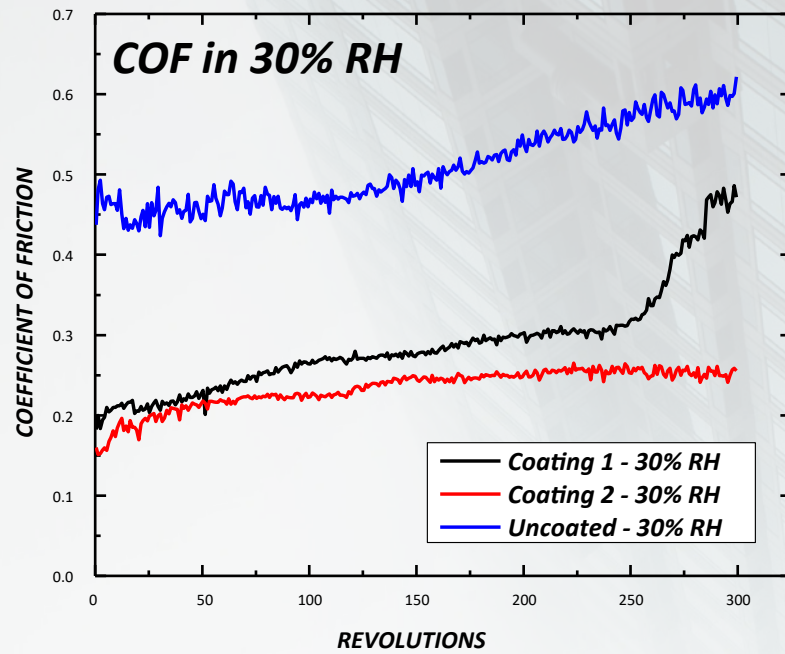
FIGURE 1: *Coefficient of friction during the pin-on-disk tests in different relative humidity.*

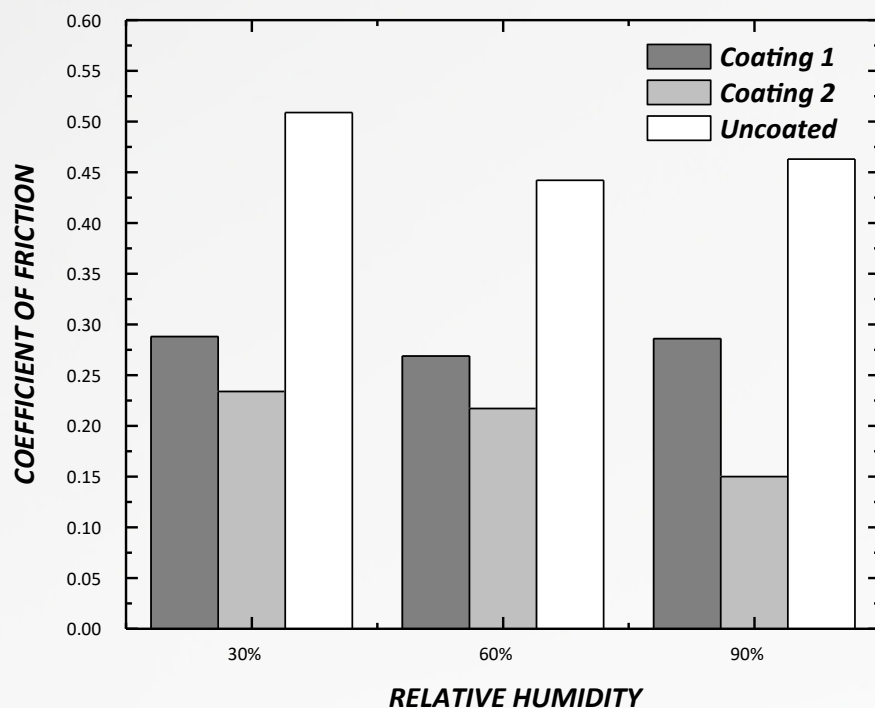**FIGURE 2:** *Average COF during the pin-on-disk tests in different relative humidity.*

FIGURE 3: *Formation of small water droplets on the coated glass surface.*

FIGURE 4 compares the wear tracks on the glass surface after the wear tests in different humidity. Coating 1 exhibits signs of mild wear after the wear tests in the RH of 30% and 60%. It possesses a large wear track after the test in the 90% RH, in agreement with the significant increase of COF during the wear test. Coating 2 shows nearly no sign of wear after the wear tests in both dry and wet environment, and it also exhibits constant low COF during the wear tests in different humidity. The combination of good tribological properties and low surface energy makes Coating 2 a good candidate for self-cleaning glass coating applications in harsh environments. In comparison, the uncoated glass shows larger wear tracks and higher COF in different humidity, demonstrating the necessity of self-cleaning coating technique.
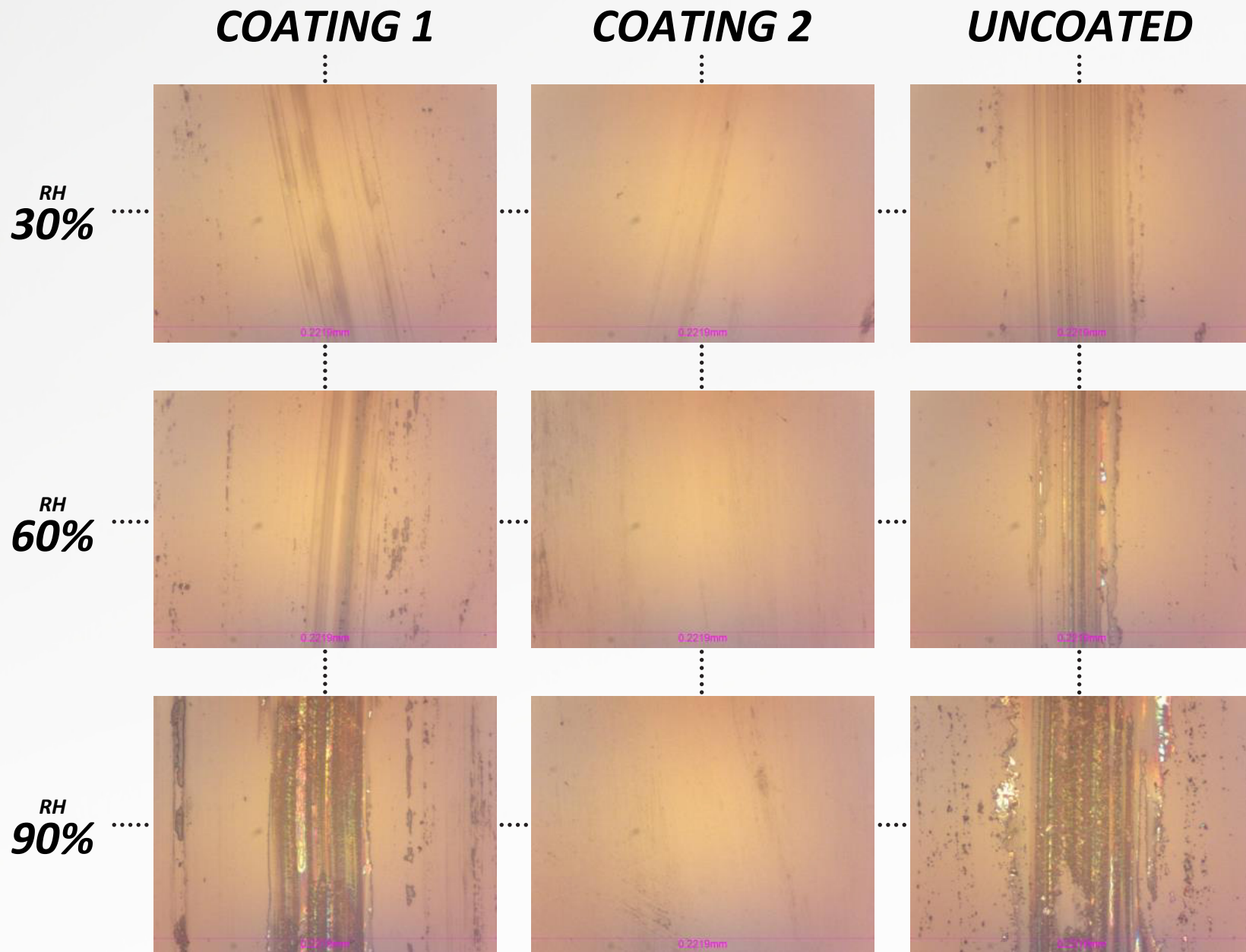
FIGURE 4: *Wear tracks after the pin-on-disk tests in different relative humidity (200x magnification).*

CONCLUSION

NANOVEA T100 Tribometer is a superior tool for evaluation and quality control of self-cleaning glass coatings in different humidity. The capacity of in-situ COF measurement allows users to correlate different stages of wear process with the evolution of COF, which is critical in improving fundamental understanding of the wear mechanism and tribological characteristics of the glass coatings. Based on the comprehensive tribological analysis on the self-cleaning glass coatings tested in different humidity, we show that Coating 2 possesses a constant low COF and superior wear resistance in both dry and wet environment, making it a better candidate for self-cleaning glass coating applications exposed to different weathers.

NANOVEA Tribometers offer 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. Optional 3D non-contact profiler is available for high resolution 3D imaging of wear track in addition to other surface measurements such as roughness.

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