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GLASS WEAR WITH DIFFERENT POWDERS (EUTALLOY TUNG TEC, METCO 82VF-NS AND MTS 8013)

BY

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Abstract. This study investigates the wear behavior of glass when subjected to abrasion by three different powders: two chromium-based and one ceramic-based. The experiments were conducted using a tribometer with a constant rotational speed, evaluating the wear over operation times of 1 hour and 2 hours. The focus was on the progressive wear of the glass surface and the noise levels emitted by the powders within a rotary mass tribosystem. Results indicate that the wear rate and acoustic emissions vary depending on the type of powder and the duration of operation. Beyond their application in wear testing, these powders show potential for use in polishing processes and coating applications, emphasizing their versatility in tribological and surface engineering domains.

Keywords: polishing powders, ceramic glass, friction, abrasion powders, acoustic.

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1. Introduction

Wear between glass and particles is a critical concern in many industrial and technological applications, where particles can interact with glass surfaces, leading to significant degradation over time. This interaction is mainly governed by abrasive wear mechanisms, in which particles embedded in a moving surface or suspended in a fluid medium become abrasive to the glass surface through repeated contact. The severity of wear is influenced by several factors, including particle hardness, size, shape, and concentration. Harder particles, such as silicon carbide or alumina, tend to penetrate the glass surface more easily, resulting in micro-cutting and scratching actions that remove material from the glass (Mens and De Gee, 1991; Mohan *et al*., 1970). Particle size and shape also play important roles. Larger, more angular particles typically cause more severe wear compared to smaller, rounded particles due to increased cutting efficiency and higher localized stresses (Belkhir *et al*., 2009). In addition, the concentration of particles in the interacting medium affects the wear rate, with higher concentrations leading to increased abrasion and material removal (Zhao *et al*., 2021).

Metco 82VF-NS (Cr_2O_3) is particularly recognized for its high hardness and wear resistance, making ita popular choice for applications requiring extreme durability (Author et al., Year). Recent studies have also investigated the impact of Cr_2O_3 on the mechanical properties of ZTA composites. For example, the addition of nano- and micron-sized Cr_2O_3 powders to ZTA composites resulted in a slight decrease in densification and elastic modulus but led to a significant increase in flexural strength due to the formation of compressive stresses at the grain boundaries (Usta and Yildiz, 2023)

Recent investigations into the wear mechanisms of tungsten carbide and glass interfaces near the glass transition temperature have revealed significant insights into the friction behavior and surface modifications under high temperature conditions (Chizhik *et al*., 2020). Using a newly developed tribometer capable of operating at high temperatures, the researchers analyzed the friction properties of B270 soda-silica glass and found that the friction coefficient values remain relatively stable at temperatures well below the glass transition point. However, a systematic increase in the friction coefficient was observed as the temperature approached the glass transition, which was attributed to various surface modification regimes, including cracking, plastic deformation, and viscoelastic deformation. Similar trends were observed in polymethyl methacrylate (PMMA) used as a complementary material. Despite the comprehensive data collected, pin-on-disk measurements could not unambiguously distinguish the direct effects of different dissipation channels from those caused by changes in contact area and adhesion (Lee *et al*., 2022).

In recent studies, the composites exhibit promising properties, such as low thermal expansion and high resistance to thermal shock, making them suitable for applications like high-temperature gas filters and lightweight structural components. In this work, composites based on ZrO_2 – CA_2, were fabricated from mixtures of m-ZrO_2 and high-alumina cement using uniaxial pressing and conventional sintering. Researchers focuses on the effets of phase composition, sintering temperature, and particle size of ZrO_2 on textural characteristics (porosity, pore size), microstructure, and mechanical properties (Yesica *et al*., 2016).

2. Experimental study

The purpose of this study is to observe the influence of powders on the glass application process.

Three types of powder were chosen for this study as can be seen in Fig. 1, Eutalloy Tung Tec, MTS 8013 and Metco 82VF-NS (Kumar *et al*., 2004; Istrate *et al*., 2016).

The fundamental characteristics of these powders are summarized below:

1. Eutalloy Tung Tec:
    - Shape: Spherical, promoting uniform flow and deposition.
    - Particle Size: Typically ranges between 45–90 µm.
    - Composition: High tungsten content, designed for wear-resistant coatings.
2. MTS 8013:
    - Shape: Angular, improving mechanical bonding.
    - Particle Size: Ranges from 20–60 µm.
    - Composition: Zirconia stabilized with calcium oxide, providing high thermal stability.
3. Metco 82VF-NS:
    - Shape: Semi-spherical, facilitating consistent application.
    - Particle Size: Ranges between 45+5.5 µm.
    - Composition: Chromium carbide-based, offering excellent wear resistance, corrosion protection and sliding wear protection.
    - Max. service temperature: 870°C.

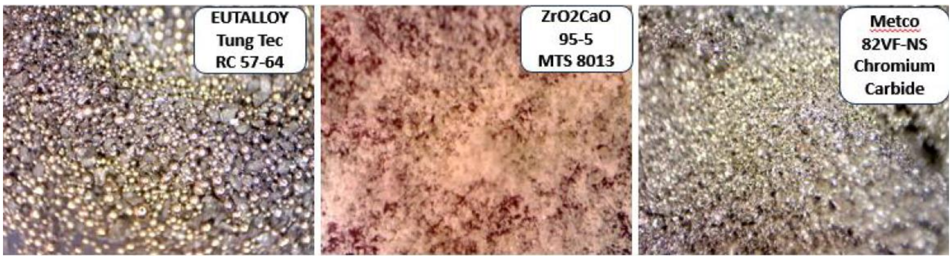


Fig. 1 – Types of powders using for this test. 180x

The cloth was impregnated with powders and subjected to certain loads on the tribometer table at a rotation speed of 500 rpm for different times, respectively 1h and 2h.

Figure 2 shows the microfiber cloth impregnated with MTS 8013 ceramic powder. The powder is on both the cloth and the glass surface to ensure uniform contact at the start of the test.

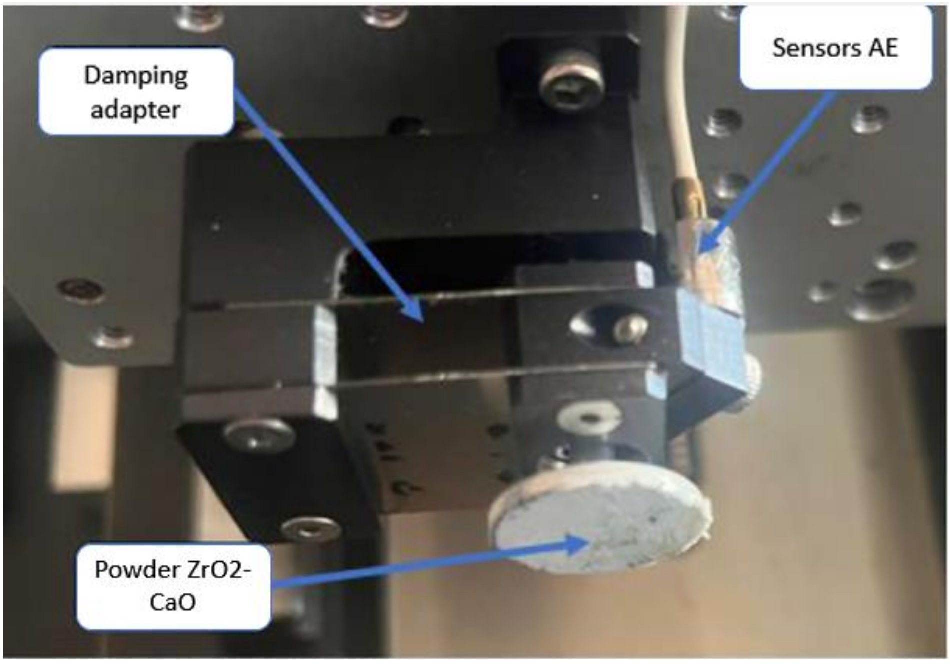


Fig. 2 – Detail of tribosystem impregnated cloth with MTS 8013 powder.

3. Results and discusion

Figure 3 shows the behavior of the friction force as a function of time for the three types of powders. The analysis highlights significant differences in the evolution of the friction force for each type of powder.

Tung Tec powder exhibits a similar behavior to Metco 82 VF powder. The friction force reaches a peak of 0.41N at 500 seconds, followed by a decrease to 0.27N at 1000 seconds. After this period, the friction force remains constant around 0.27N for the remainder of the test. This behavior indicates a rapid stabilization of the friction and a constant wear, similar to that observed with MTS 8013, but with lower values of the friction force.

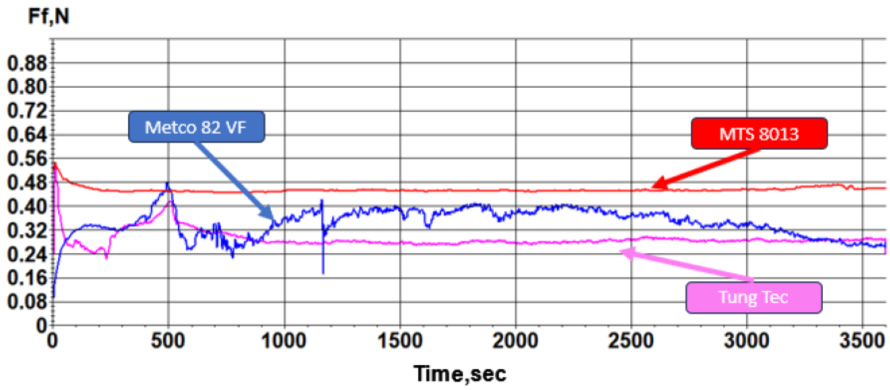


Fig. 3 – Variation of force Ff in time.

In the case of Metco 82 VF powder, the friction force reaches a maximum value of 0.48 N at 500 seconds. After this point, a decrease to 0.32 N is observed, followed by fluctuations around 0.4 N. After 2300 seconds, the friction force gradually decreases to 0.25 N. This behavior suggests an initial stabilization phase, followed by a period of variable wear, and finally, a gradual reduction in friction. MTS 8013 powder shows a small decrease from 0.56 N for the initial area reaching a value of 0.48 and remains constant throughout the test, which indicates a lack of glass wear. MTS 8013 powder has an initial coefficient of friction of 0.14, which rapidly decreases to 0.09 in the first 351 seconds and remains constant at this value throughout the test. Metco 82 VF powder exhibits significant fluctuations in the coefficient of friction, reaching a maximum of 0.09 at 500 seconds. After this point, the coefficient of friction gradually decreases and stabilizes around 0.07 towards the end of the test. Tung Tec powder exhibits a similar behavior to Metco 82 VF powder.

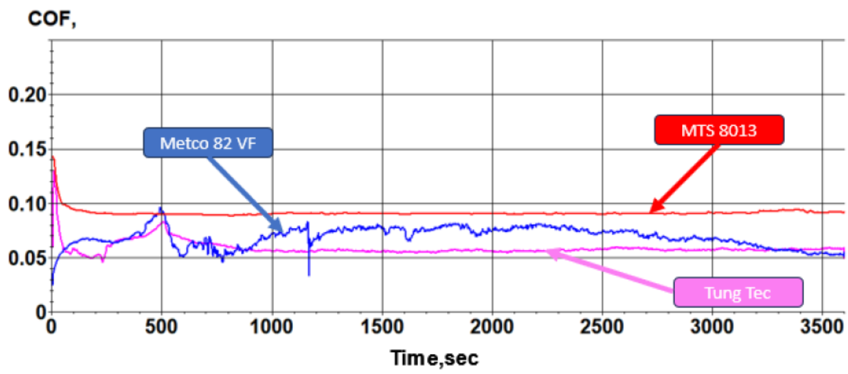


Fig. 4 – Variation of the friction coefficient with time for the three types of powder.

The coefficient of friction (COF) reaches a maximum of 0.09 at 500 seconds, followed by a gradual decrease over a period of 500 seconds, until it reaches a value of 0.06. After this point, the coefficient of friction remains constant at 0.06 throughout the entire 3600 second test.

Metco 82 VF and MTS 8013 powders show significant initial fluctuations and subsequent stabilization, but with higher force and friction coefficient values compared to Tung Tec powder. In particular, MTS 8013 shows rapid stabilization at a relatively low friction coefficient, but with a higher constant friction force. Figure 5 shows the noise analysis, measured with the tribometer sensor, where the tests performed with Metco 82 VF show a more pronounced noise compared to that with MTS 8013, although the noise level is equally high.

In this study, AE testing was employed due to its ability to provide real-time, non-destructive monitoring of material integrity. By analyzing the AE signals, it becomes possible to identify and characterize critical events within the material under test. Figure 5 presents the results of AE testing, illustrating the correlation between emission activity and material behavior during the experimental process.

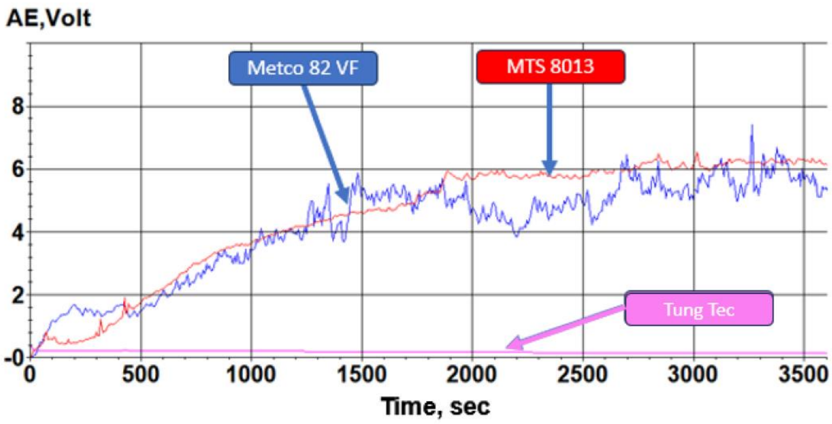
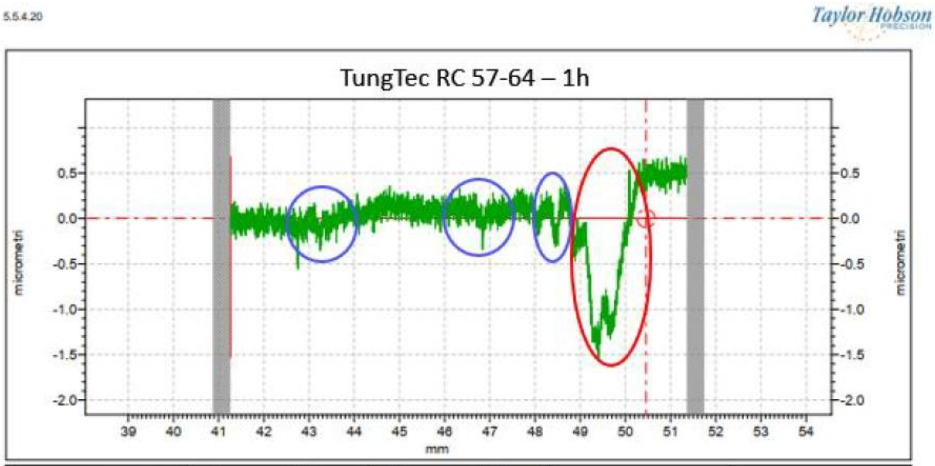


Fig. 5 – Noise variation over time for the 3 powders.

Tung Tec powder has the lowest noise level in the testing process of the impregnated cloth on glass. The analysis of the glass surface condition after the wear tests was performed on the profilometer for the sample where the cloth was impregnated with Tung Tec, the analysis was performed on the entire wear area where several wear areas can be observed in Fig. 6. Towards the outside of the worn part, a more pronounced wear area is observed both on the profilometer and in a visual analysis.



			Slope	0.238	°	Pz(JIS)	1.0003	µm						
Pa	0.2064	µm	Pq	0.3459	µm									
Psk	-1.9972		Pku	8.1930										
Pp	0.6817	µm	Pv	1.5286	µm	Pmr(C) (1)	63.15	%	Height (mean)	0.000	µm			
PLo	10.1120	mm	Pt	2.2103	µm	PHSC (1)	107	peaks	Height (mean)	0.000	µm			
Plq	35.60	µm	Pdq	3.49	°	Pdc (1)	2.2103	µm	mr1%	0.00	%	mr2%	100.00	%
Pda	2.57	°	Pz	2.2103	µm	Pmr (1)	50.00	%	offset	0.000	µm	mr%	50.00	%
PS	17.60	µm	PSm	2920.75	µm	PVo (1)	0.0127	vol	offset	0.000	µm	mr%	50.00	%
Pln	10.0950	mm	Pc	1.2845	µm	PPc (1)	529.0	pks/cm	Height (mean)	0.000	µm			
									bandwidth	0.00	µm			

Fig. 6 – Profilometer analysis for Eutalloy Tung Tec powder on glass.

Figure 7 highlights a detailed view of the region with the most significant glass wear, where the wear depth reaches approximately 1.5 micrometres. In the wear area, an observable increase in surface height is evident, which indicates the presence of a powder deposit.

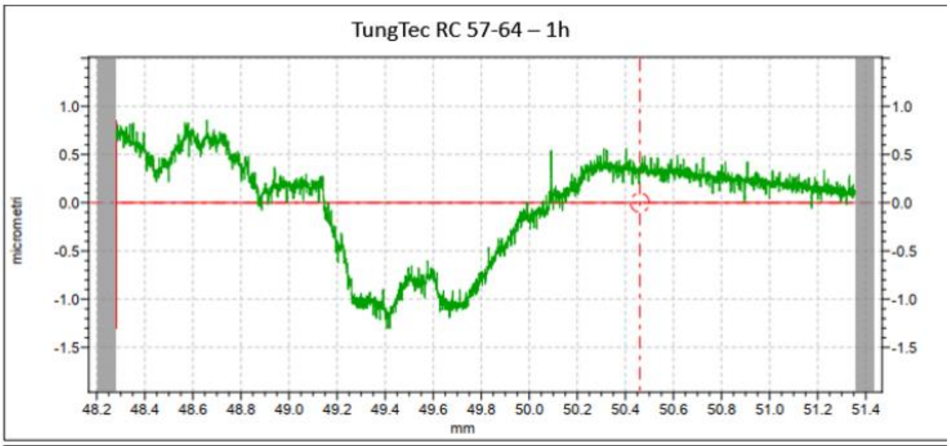


Fig. 7 – Detail of the worn area for Eutalloy Tung Tec powder, highlighted in red in Fig. 6.

When analyzing the tests conducted with Metco 82VF-NS powder in comparison to Eutalloy Tung Tec powder, it is evident that the wear is significantly reduced, reaching values as low as 0.25 microns, as illustrated in Fig. 9.

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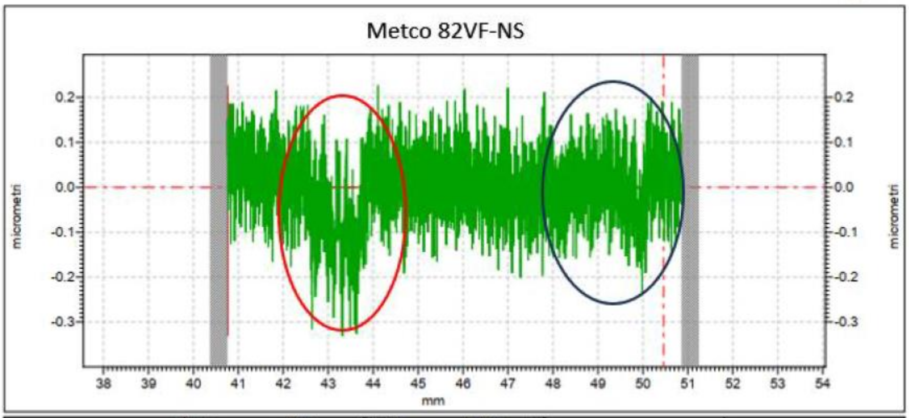
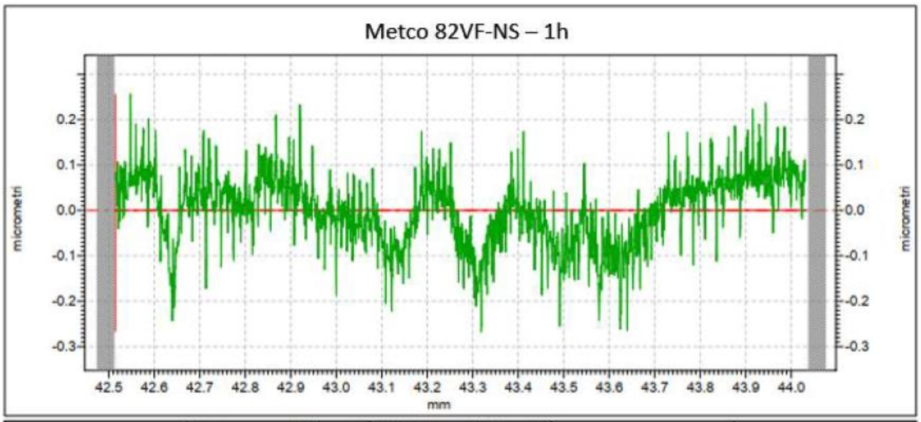


			Slope	0.282	°	Pz(JIS)	0.5335	µm						
Pa	0.0434	µm	Pq	0.0602	µm									
Psk	-0.8485		Pku	5.3172										
Pp	0.2257	µm	Pv	0.3304	µm	Pmr(C) (1)	56.63	%	Height (mean)	0.000	µm			
PLo	10.1099	mm	Pt	0.5561	µm	PHSC (1)	971	peaks	Height (mean)	0.000	µm			
Plq	6.60	µm	Pdq	3.28	°	Pdc (1)	0.5561	µm	mr1%	0.00	%	mr2%	100.00	%
Pda	2.40	°	Pz	0.5561	µm	Pmr (1)	50.00	%	offset	0.000	µm	mr%	50.00	%
PS	4.70	µm	PSm	10095.00	µm	PVo (1)	0.0025	vol	offset	0.000	µm	mr%	50.00	%
Pln	10.0950	mm	Pc	0.5455	µm	PPc (1)	1564.2	pks/cm	Height (mean)	0.000	µm			
									bandwidth	0.00	µm			

Fig. 8 – Profilometer analysis for Metco 82VF-NS powder on glass.



			Slope	0.263	°	Pz(JIS)	0.4774	µm						
Pa	0.0618	µm	Pq	0.0769	µm									
Psk	-0.3262		Pku	3.0899										
Pp	0.2561	µm	Pv	0.2664	µm	Pmr(C) (1)	53.93	%	Height (mean)	0.000	µm			
PLo	1.5196	mm	Pt	0.5225	µm	PHSC (1)	91	peaks	Height (mean)	0.000	µm			
Plq	7.96	µm	Pdq	3.48	°	Pdc (1)	0.5225	µm	mr1%	0.00	%	mr2%	100.00	%
Pda	2.56	°	Pz	0.5225	µm	Pmr (1)	50.00	%	offset	0.000	µm	mr%	50.00	%
PS	4.65	µm	PSm	301.75	µm	PVo (1)	0.0035	vol	offset	0.000	µm	mr%	50.00	%
Pln	1.5175	mm	Pc	0.4579	µm	PPc (1)	896.5	pks/cm	Height (mean)	0.000	µm			
									bandwidth	0.00	µm			

Fig. 9 – Detail of the worn area for Metco 82VF-NS powder, highlighted in red in Fig. 8.

When comparing the noise levels, it is evident that the Tung Tec powder exhibits the lowest noise level but the highest wear, in contrast to the Metco powder. The MTS 8013 powder, however, did not display any measurable signs of wear; consequently, no profilometer analysis was presented for this material.

4. Conclusions

The experimental study on the wear of glass by friction with various materials provided valuable information about the behavior of glass under pressure and friction conditions at variable speeds.

Eutalloy Tung Tec powder showed the most consistent performance in terms of friction force and generated the lowest noise level, indicating uniform and minimal wear on the glass.

Metco 82VF-NS powder generated higher noise and fluctuations in friction force, suggesting a more aggressive interaction with the glass surface.

MTS 8013 powder showed significant increases in friction force and wear, making it less ideal for applications requiring minimal wear.

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UZURA STICLEI CU DIFERITE PULBERI (EUTALLOY TUNG TEC, METCO 82VF-NS ȘI MTS 8013)

(Rezumat)

Acest studiu investighează comportamentul la uzură al sticlei atunci când este supusă la abraziune de către trei pulberi diferite: două pe bază de crom și una pe bază de ceramică. Experimentele au fost efectuate folosind un tribometru cu o viteză de rotație constantă, evaluând uzura pe timpi de funcționare de 1 oră și 2 ore. Accentul a fost pus pe uzura progresivă a suprafeței de sticlă și nivelurile de zgomot emise de pulberi într-un tribosistem de masă rotativă. Rezultatele indică faptul că rata de uzură și emisiile acustice variază în funcție de tipul de pulbere și de durata de funcționare. Dincolo de aplicarea lor în testarea uzurii, aceste pulberi prezintă potențial de utilizare în procesele de lustruire și aplicații de acoperire, subliniind versatilitatea lor în domeniile tribologice și ingineria suprafețelor.