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# Effects of relative humidity on the tribological behavior of Cu-Zr-based bulk metallic glasses

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Bulk Metallic Glasses (BMGs) are recent materials (1980s) of great interest for industrials because of their rare mechanical properties, including high elastic limit and hardness. However, their tribological behavior is still highly debated and misunderstood. The present study aims at demonstrating the influence of the relative humidity of ambient air on the friction and wear of BMGs.

## 1. Introduction

Bulk Metallic Glasses are alloys with amorphous structure, that confers them a very different mechanical behavior compared to crystalline alloys [1]. The wear resistance of BMGs is however weakly studied and seems to deliver conflicting results. Existing tribological studies analyze the impact of parameters such as chemical composition, relaxation, mechanical properties and contact conditions, but very few look into environmental conditions (argon, oxygen, vacuum) [2-3], and none of them considers relative humidity.

## 2. Materials and Methods

The Cu-Zr-based BMG chosen for this study is $Cu_{47}Zr_{46}Al_7$, because of its ease of manufacturing and its good mechanical properties. BMG plates were tested through reciprocating linear ball-on-plate friction tests (5000 cycles of 2mm magnitude at 1 Hz, with an applied normal force of 1N). The counterparts used were 100Cr6 balls. The relative humidity (RH) was controlled by means of NaOH solutions with variable concentrations.

## 3. Results and Discussion

The coefficient of friction (COF) is strongly correlated to the RH of ambient air: the COF decreases as the RH increases. The wear volume of the steel ball follows the same trend. However, the BMG wear volume remains extremely low (nearly zero) whatever the RH rate. This is due to the formation of a protective tribolayer on the BMG friction track. This layer appears mostly composed of iron oxides coming from the wear debris of the ball.

$Cu_{47}Zr_{46}Al_7$ has a promising tribological behavior because of its high wear resistance compared to the harder steel counterpart. The COF reaches high values, but this could be improved with strategies like *in situ* nano-crystallization. The high dependency of the COF to the relative humidity has to be considered for industrial applications in different countries or seasons, for which ambient humidity can vary drastically.

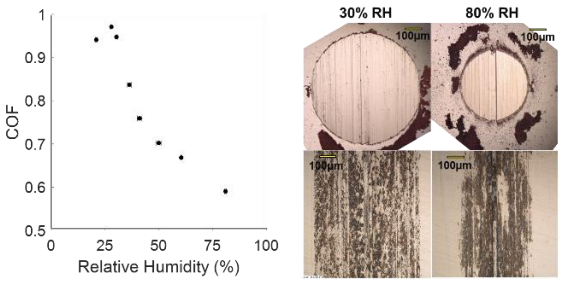


**Figure 1:** Coefficient of friction of $Cu_{47}Zr_{46}Al_7$ at different relative humidity (left), wear tracks on the ball and the plate (right).

## 4. References

[1] A. Inoue, Eng. Sci. Press,1(2) 185-191 (2015)
[2] H. Wu, Intermetallics 25, 115-125 (2012)
[3] M.R. Jones, Trib. Letters, 68-123 (2020)