Tribo-corrosion maps for application in bio-tribology: some new approaches

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1. Introduction

Advances in the study of tribo-corrosion of materials in recent years have included the development of mechanistic maps, showing the transitions between the regimes as a function of the main process parameters. In such cases, maps have been constructed in both two and three dimensions. There are now a variety of modelling algorithms which may be used to map a range of performance indicators over a multi-parameter space.

The interactions of tribo-corrosion in biological environments are becoming of increasing importance. In the wear of hip joints, tribo-corrosion maps may be used to characterize mechanism, wastage and synergistic effects i.e, Fig. 1

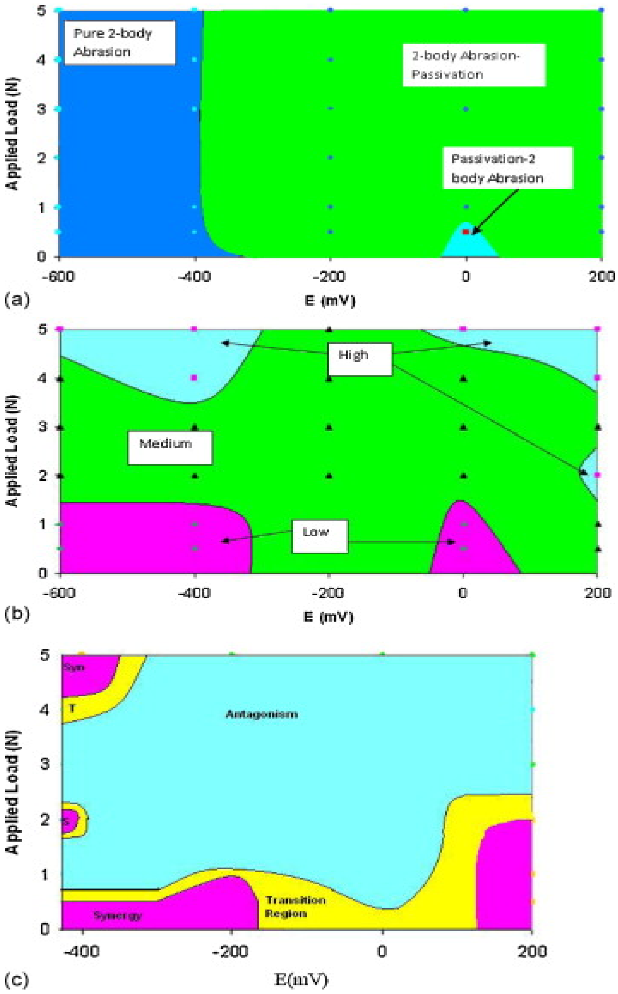

Fig.1. Micro-abrasion–corrosion maps for Co–Cr/UHMWPE in Ringer's solution. (a) Mechanism map. (b) Wastage Map. (c) Synergy map.[1].

For materials which can used in dentistry applications, tribo-corrosion maps can also be generated to describe mechanistic behavior, Fig. 2

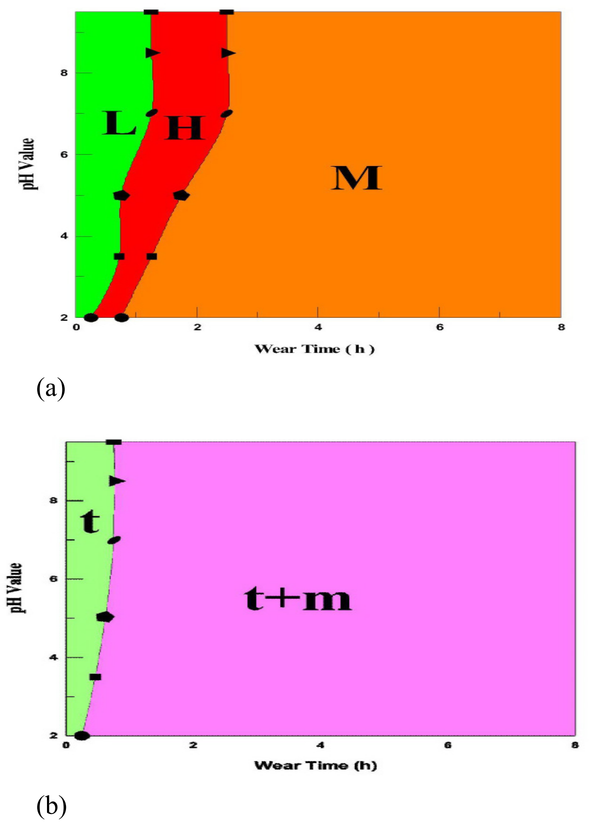

Fig.2. Erosion-corrosion maps for YTZP dental ceramics at various pH and exposure times at 90 degree impact angle (a) Wear rate e map where Green: Low, Orange: Medium, Red: High)(b) Phase stability map showing tetragonal to monoclinic transformation [2].

Hence, the various modes of tribology interacting with corrosion may be identified for bio-tribo-corrosion conditions as identified in recent published work [1-2]. These include establishing the dominance of wear against corrosion, for a candidate material, Co-Cr which is used in hip joint prostheses, Fig. 1(a), and identifying the the stability of the corrosion product, i.e. if arising from the formation of a passive film. The transitions to “unsafe” zones may be highlighted by another form of the map, Fig 1(b). For the same parameter space, Fig. 1(c), the ability of the passive film, Cr_2O_3, to resist impact may be characterized by the large “antagonistic” area, as shown on Fig. 1(c).

For YTZP- Yttria Tetragonal Zircona Polycrystalline- ceramics, which are candidate replacement materials in dental applications [2], recent research has indicated that pH and exposure time may significantly change the degradation rate of the material.　This has produced a new insight into how phase transformations in such ceramics may be accelerated in tribo-corrosion conditions.　The erosion impact angle has also been shown to have an effect on such transitions [2].　Hence, bio-tribo-corrosion maps may identify optimum exposure environments,　Fig. 2(a), and any phase change in the material, Fig. 2(b) in such conditions.

2. Summary

1. Bio-tribo-corrosion maps have been generated for a range of biological conditions, where the effects of tribo-corrosion are not well described to date.
2. Applications of these maps include hip joint prostheses and dental replacement materials.
3. Such maps can be used to identify mechanisms of degradation, extent of synergism and antagonism in the process and any change in material structure following exposure to the tribo-corrosion environment.

3. References

[1] M.M. Stack, J. Rodling, M.T. Mathew, H. Jawan, W. Huang, G. Park, C. Hodge, Wear, Volume 269, Issues 5-6, 19 July 2010, Pages 376-382.
[2] Hsin-Chun Wang, M.M. Stack, Ting-Fu Hong, Moo-Chin Wang, Wang-Long Li Tribology International, In Press, Accepted Manuscript, Available online 14 July 2010 doi:10.1016/j.triboint.2010.06.015