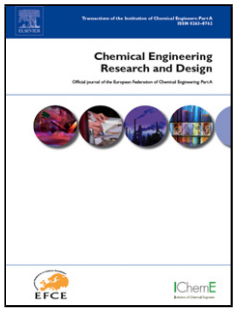

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Use of a modified Taber abrasion apparatus for investigating the complete stress state during abrasion and in-process wear particle aerosol generation

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Abstract

A present challenge in chemical nano-product formulation is the prediction of structure-function relationships of designed nano-particle based chemical engineering products such as coatings or solids. A particular attention is in this framework today paid to the question whether such products will release particles to the air during their life cycle. This aerosolization of (nano-) particles impacts possibly occupational and consumer health. A possible particle release mechanism here is simply wear, i.e. e.g. when holding, moving or walking on nano-functionalized products. This means that further to the study of aerosolization, today's chemical engineers need to be able to study wear, enabling them to make future products 'nanosafe by design'.

The present article presents an affordable option for knowing the complete stress state, including both normal and tangential stresses, acting during alternated sliding abrasion when measuring the response of a surface to its wear. For this, a standard Taber™ linear abrasion 5750 apparatus is modified by adding a strain gauge and further coupled with a particle counter and particle sizers for quantifying the release of wear particles in air during abrasion. After the calibration, the modification is validated by comparing the force measurements with that of a commercial tribometer. Different case studies which were carried out using this modified apparatus show (i) clearly visible static and dynamic friction ranges (ii) clear dependency of the wear behavior and the particle aerosolization on the chosen couple material-abraser.

Keywords:
Nanosafety by Design, Abrasion, Friction, Wear, Debris, Aerosol, Tribometer, Taber

1. Introduction

Since the introduction of the Taber abrasion apparatus in 1930's, it has become a popular instrument for evaluating abrasion and wear resistance of a wide spectrum of materials (including plastics, coatings, laminates, leather, paper, ceramics, carpets, safety glazing, etc.) [Shandilya et al., 2014a]. Easy to operate, the instrument is also referenced in numerous internationally recognized test standards [ASTM, 1996, 2007, 2008]. With no limitation on the nature of surface (i.e. flat, concave, convex or mix), there is no limit on the sample sizes too. Moreover, its reasonable cost makes it affordable for small scale enterprises and research laboratories. Owing to a robust design, there have been some attempts in the past to modify this standard abrasion apparatus. For instance, the decreasing protection of organic coatings