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Measurement of the tensile strength of organic materials

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Abstract

The early formation of planets in the solar system and the activity of comets are strongly influenced by the tensile strength of astrophysical materials. To measure the tensile strength of relevant granular materials we developed a method that uses the Brazilian Disk Test. In this work we use it with organic material and study the influences of the volume filling factor, the grain size and the temperature.

1. Introduction

The tensile strength of a material is an important mechanical dimension and represents the maximum tensile force the material can resist. In astrophysics it plays an important role because it influences the interaction between particles. During planet formation in the early solar system, aggregates of mm-size were built by collisions of smaller particles. Later, bigger aggregates collided and formed lager bodies [3, 5]. The outcome of these collisions is strongly dependent on the tensile strength.
The tensile strength of organic materials has also an important impact of the dust activity of comets. The tensile strength has to be overcome by the gas pressure of sublimating ices to be ejected [2]. Several organic materials were detected in the coma of 67P/C-G [1]. Therefore, following up from the study of the tensile strengths of silicates and ices [4], it is important to measure the tensile strengths of organics relevant to comets. Additionally, the influence of parameters like the volume filling factor and temperature is essential.

2. Experimental Setup

To measure the tensile strength of granular materials, we choose to use the Brazilian Disk Test. For this test, the studied material is pressed into a cylindrical shape. We then apply a pressure from the top until the material breaks. The tensile strength can be recalculated by following equation: [6]

$$\sigma = \frac{2\,F}{\pi\,l\,d}, \tag{1}$$

where F is the maximum force applied before the material broke, d the diameter and l the length of the cylindrical sample.
The setup used can be seen in Fig. 1. The pressure is applied on the studied material with the help of a loading platen. The pressure is gradually increased and recorded with the help of a scale. The first experiments were performed at room temperature. To examine the temperature dependence of the tensile strength of organics, future measurements will be performed with the setup and samples cooled down to under 150 K.
For this study we decided to use three different organics: humic acid, paraffin and graphite (see Fig. 2). To study the influence of grain size, we used two sizes of graphite: 4,15 μm and 10,75 μm in radius.

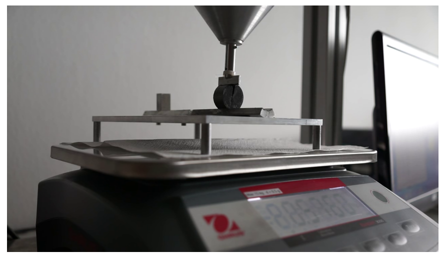

Figure 1: Experimental setup: the scale measures the pressure applied by the loading platen while pushing onto a cylinder of graphite.

3. Results

Fig. 3 shows a typical profile of the exerted load for a measurement. First, the loading platen is lowered, but has no contact to the sample. When the loading platen touches the sample and compresses it, the strength curve increases until it breaks. After the break the strength decreases immediately. It can stay above

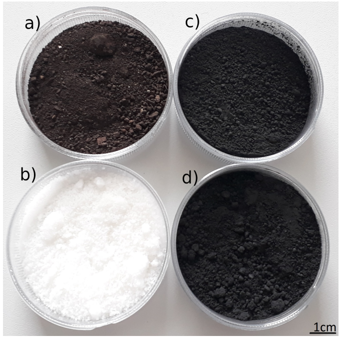

Figure 2: Used organic materials: a) humic acid, b) paraffin, c) graphite, 10,75 μm in radius, d) graphite, 4,15 μm in radius.

zero when the loading platen has contact with the rest of the sample.
As expected, the tensile strength of graphite decreases

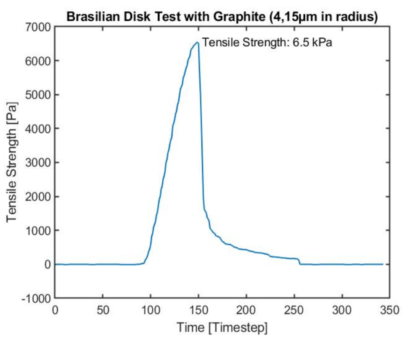

Figure 3: Example of a typical tensile strength measurement with graphite, 4,15 μm in radius. The maximum strength value at the peak corresponds to the tensile strength of the material.

with increasing grain size and decreasing volume filling factor. The dependency of the volume filling factor varies for the different materials. More detailed results, including the temperature dependency will be presented at the EPSC-DPS 2019.

4. Summary and Conclusions

In this work the Brazilian Disk Test is used to measure the tensile strength of organic comet analogue material, like graphite, paraffin and humic acid. The goal is to study different dependencies of the tensile strength. The influences of the volume filling factor, the grain size and the temperature were measured. The chosen organics have a very varying tensile strength, which can be higher and lower than the tensile strength of silica. These values could prove to be very useful for future planetary formation and cometary models.

Acknowledgements

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