

Towards green lubrication: Study of tribological properties of vegetable oil added with graphite as additives for lubricants

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Outline

- * Context of the work

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- *

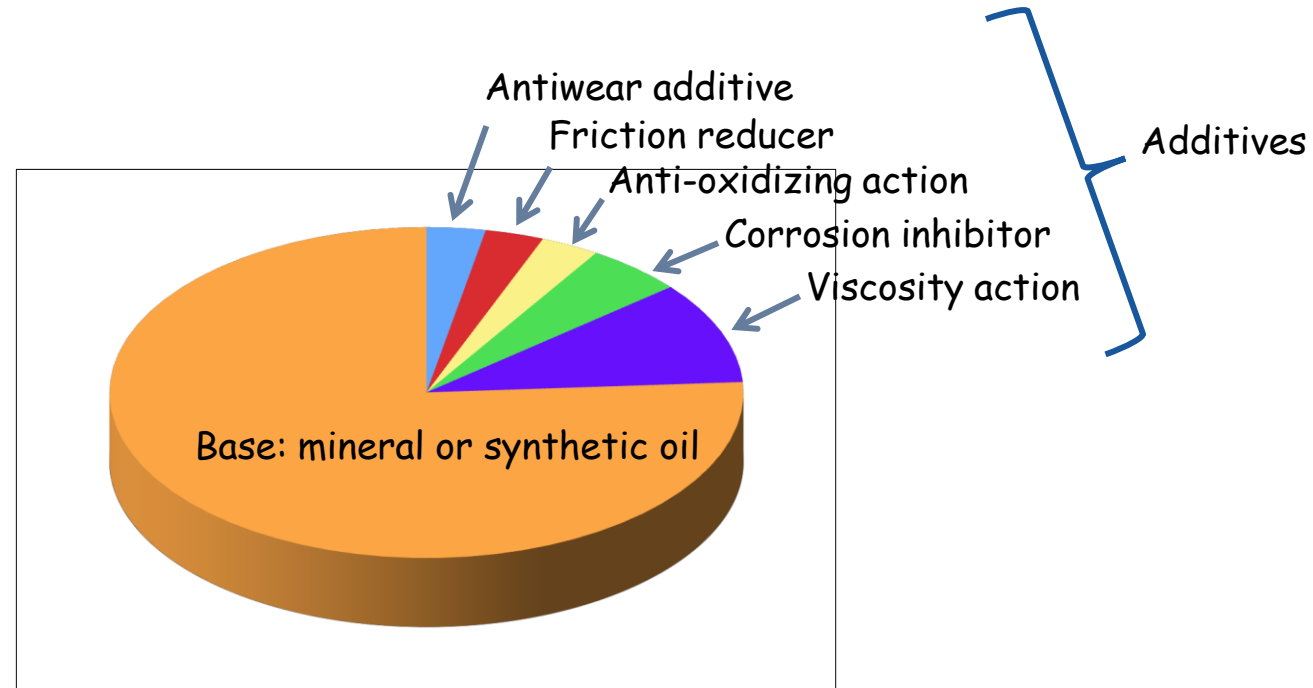
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- * Conclusions

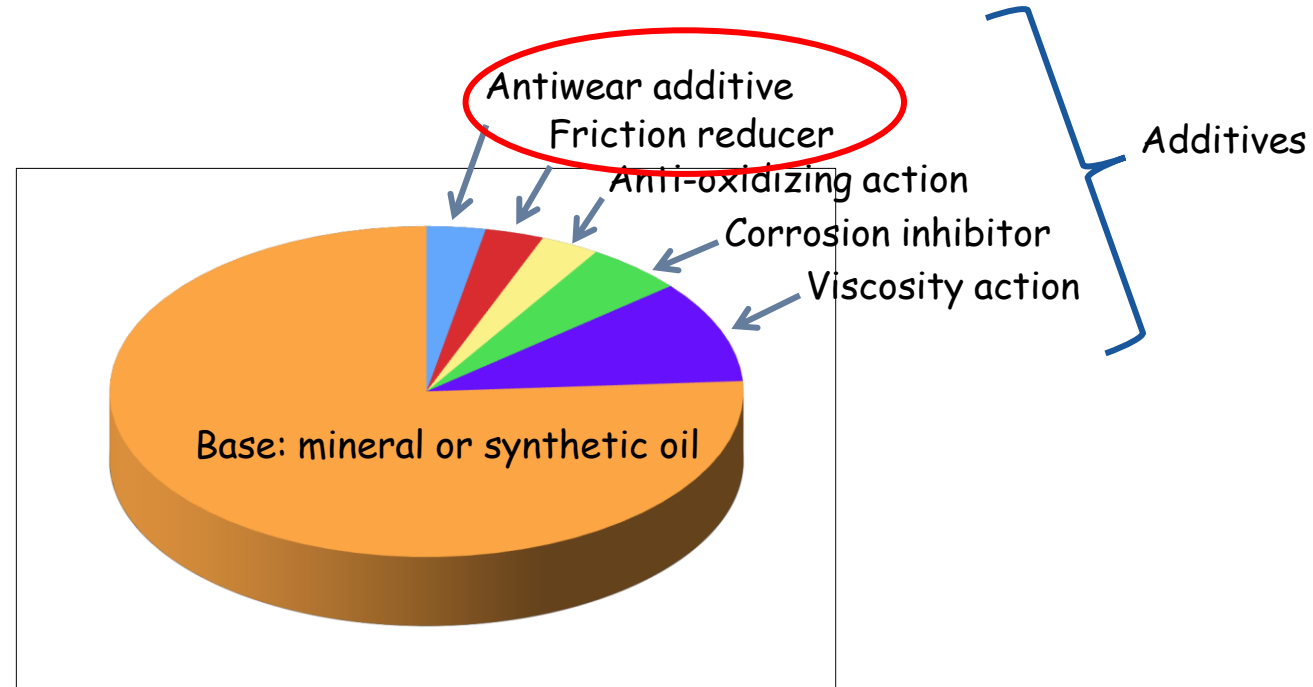
Context: liquid lubrication

Liquid lubricant: base + additives



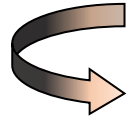
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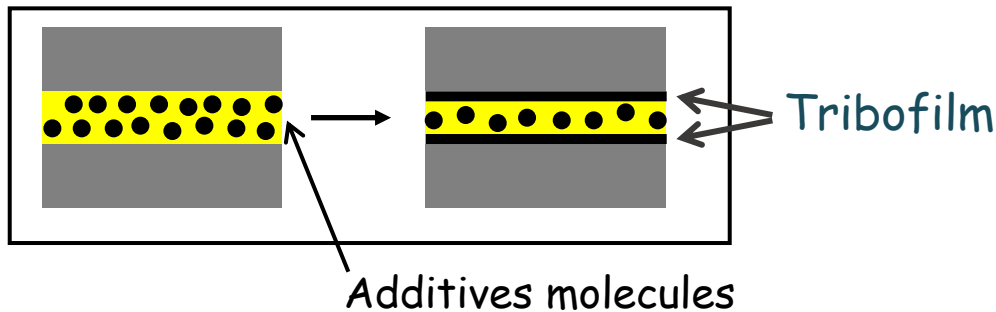


Context: liquid lubrication

Conventional additives: Zinc DialkyDithiophosphate (ZDDP), Molybdenum Dithiophosphate (MoDTP) or Dithiocarbamate (MoDTC)



Built up of a protective tribofilm resulting from chemical reactions between additives molecules and surfaces

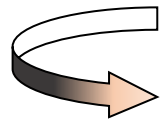


But

- The tribofilm is not immediately built (induction period) → severe wear undergone by the substrates
- The protective action is not efficient in the case of non-reactive sliding surfaces (ceramics,...)

Context: liquid lubrication

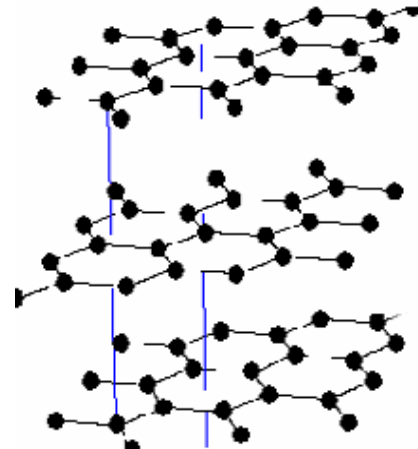
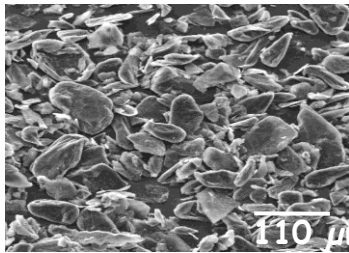
New additives: solid particles subjected to form the tribofilm in the sliding conditions without any chemical reactions with the substrates



Phases are selected according to their intrinsic friction properties

Lamellar structure particles

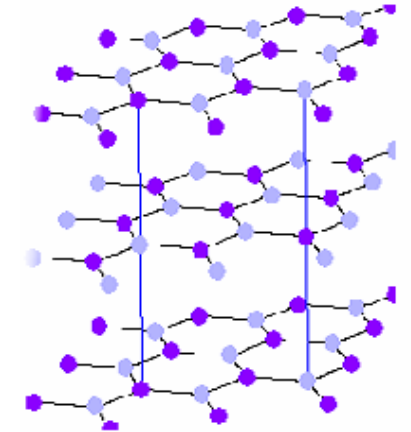
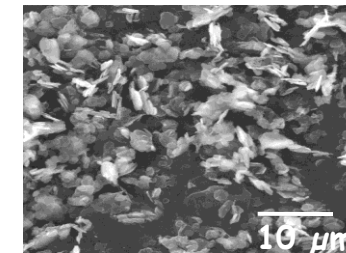
Graphite



Shape Oval and flattened

Thickness 8 μm

Hexagonal boron nitride hBN

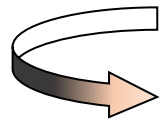


Rounded and flattened

0,2 μm

Context: liquid lubrication

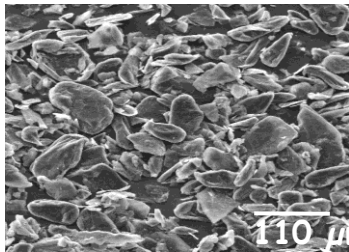
New additives: solid particles subjected to form the tribofilm in the sliding conditions without any chemical reactions with the substrates



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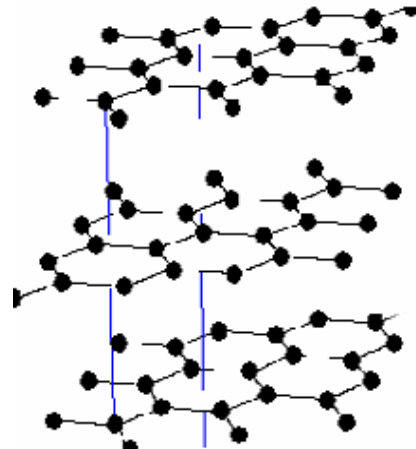
Lamellar structure particles

Graphite

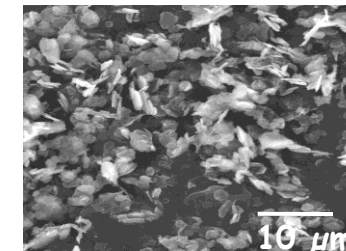


Shape Oval and flattened

Thickness 8 μm

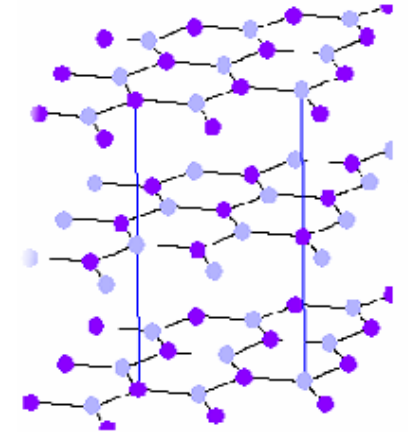


Hexagonal boron nitride hBN



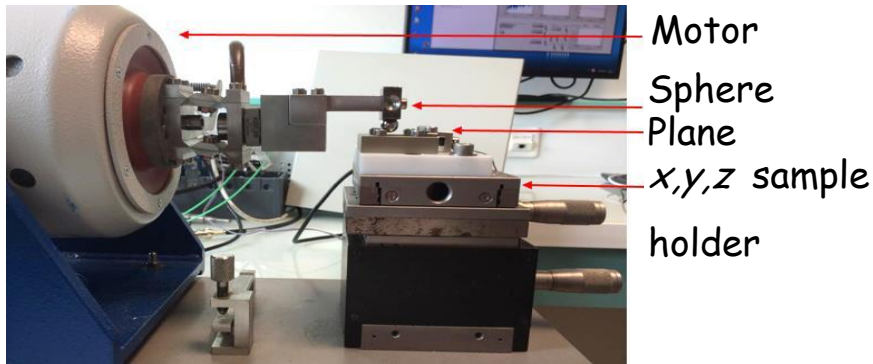
Rounded and flattened

0,2 μm

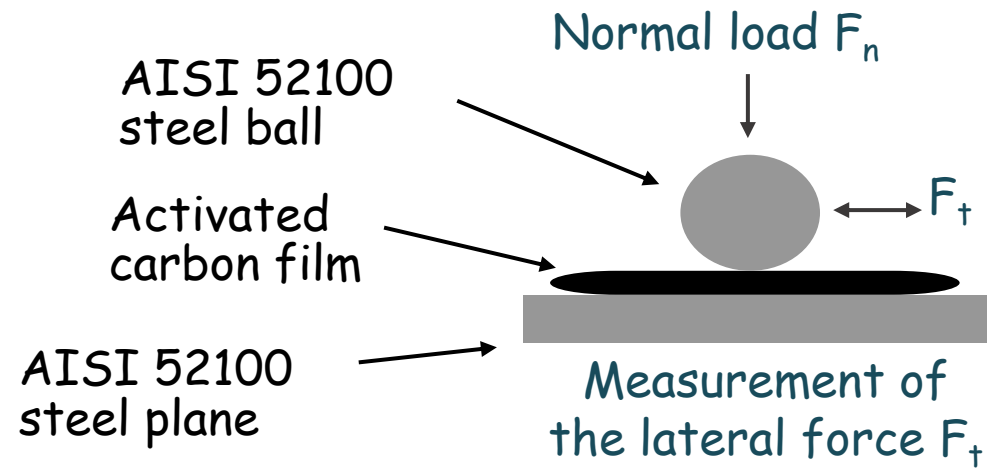


Evaluation of the influence of the presence of liquid on the tribological properties of the solid particles

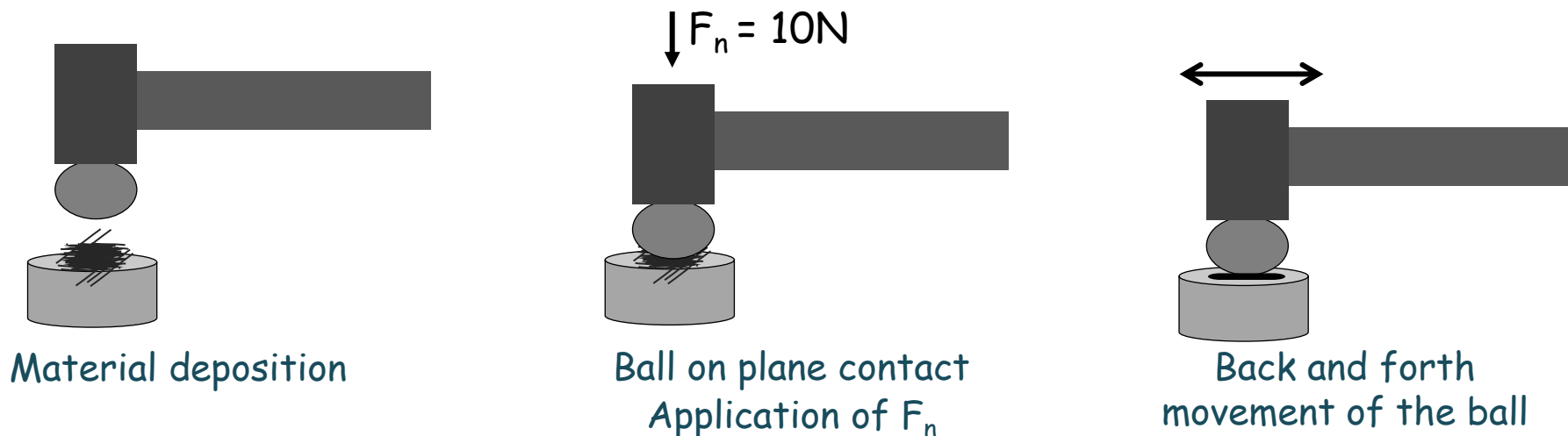
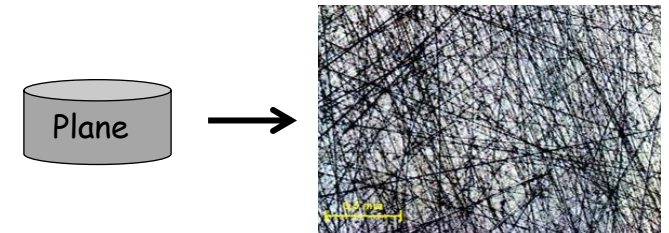
Tribologic experimental device



- Normal load: 10 N
- Contact area diameter: 140 μm (Hertz Theory)
- Maximum contact Pressure: 1 GPa
- Sliding speed: 2-3 mm/s

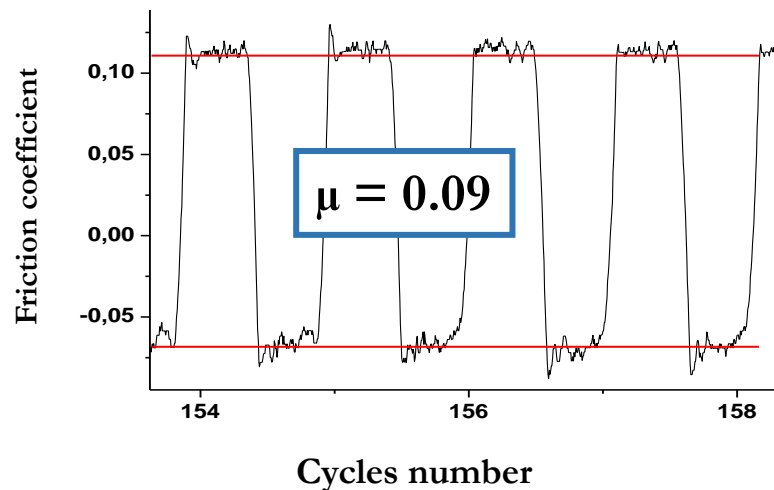
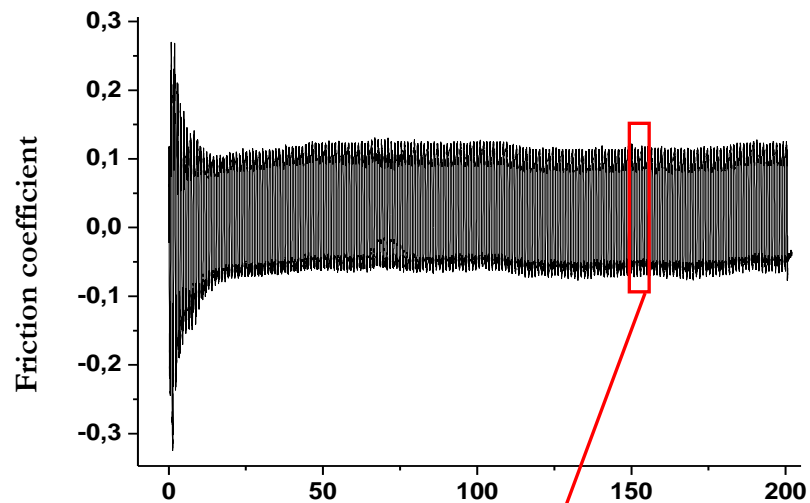


Friction coefficient $\mu = F_t / F_n$

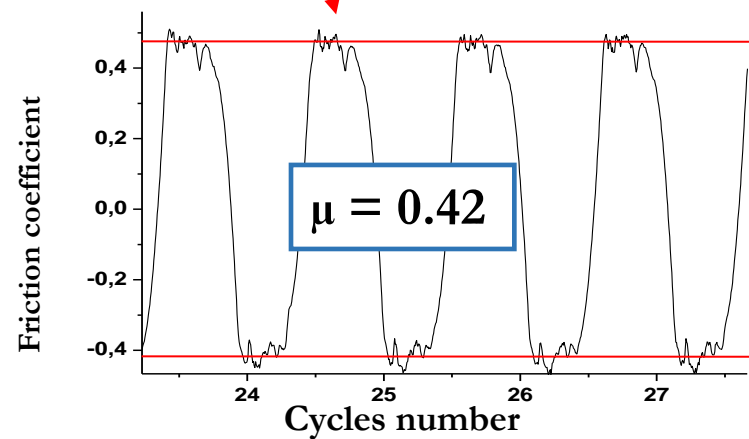
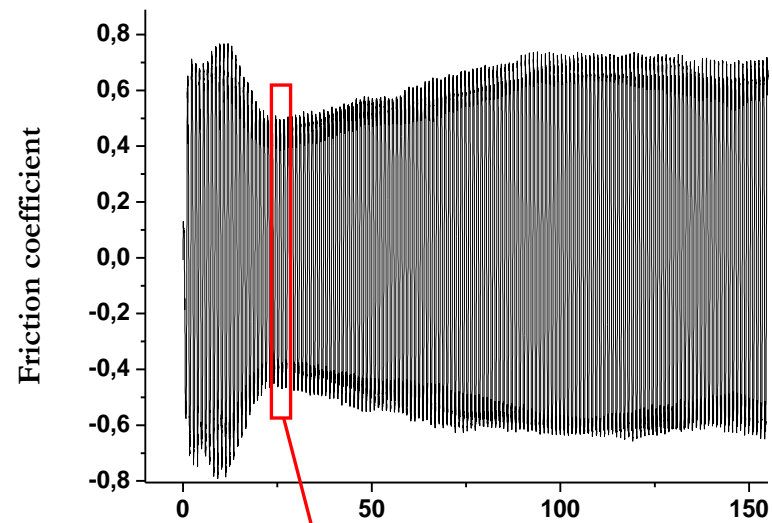


Friction properties of the particles

Graphite

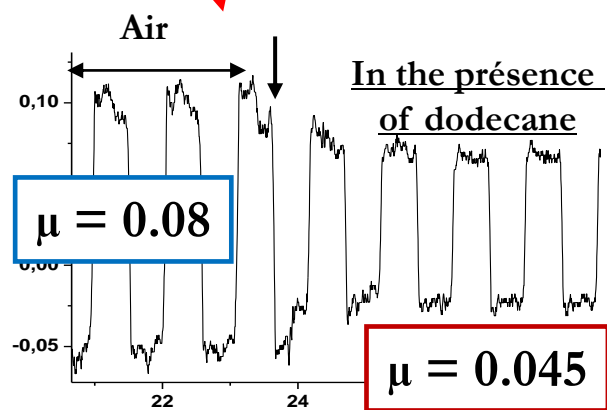
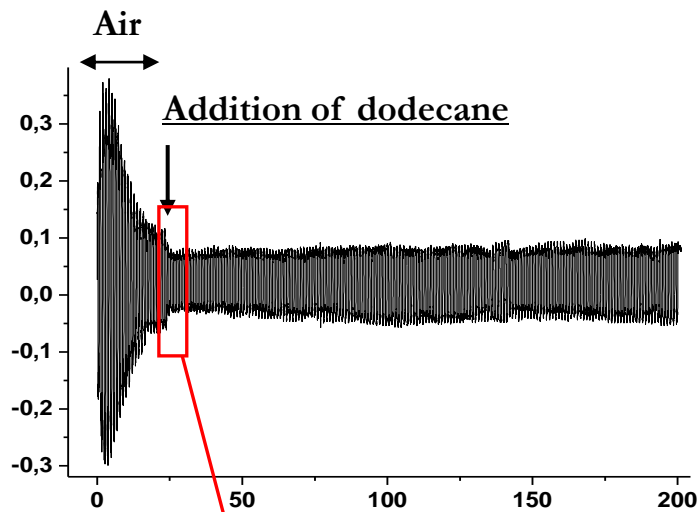


Hexagonal boron nitride h-BN



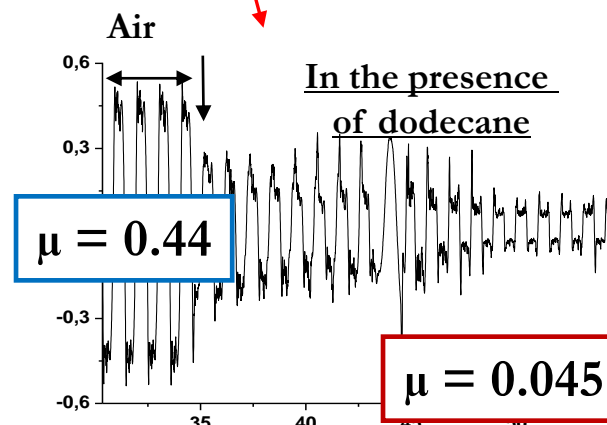
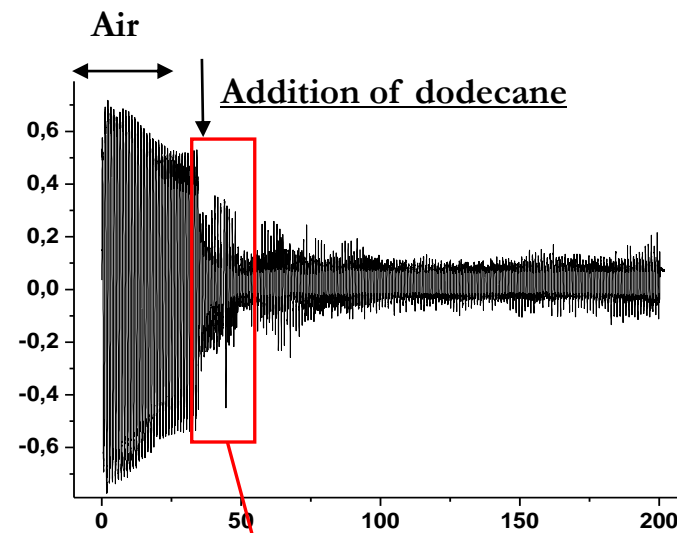
Friction properties in the presence of liquid

Graphite



Cycles number

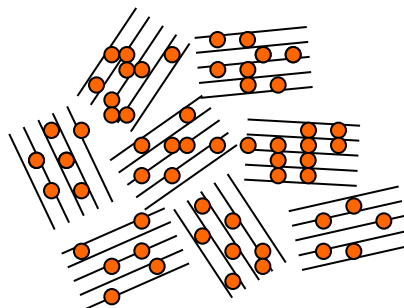
Hexagonal boron nitride h-BN



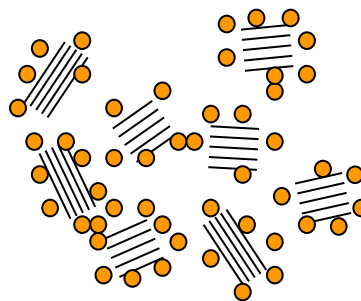
Cycles number

3 Hypothesis to explain the reduction

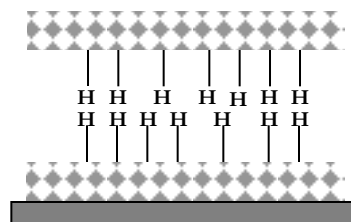
Intercalation of the organic molecules in the van der Waals gaps



Adsorption of organic molecules in the surface



Lubrication by hydrogen



Increase of the interlayer distance



Reduction of the interlayer interaction



Modification of the material structure



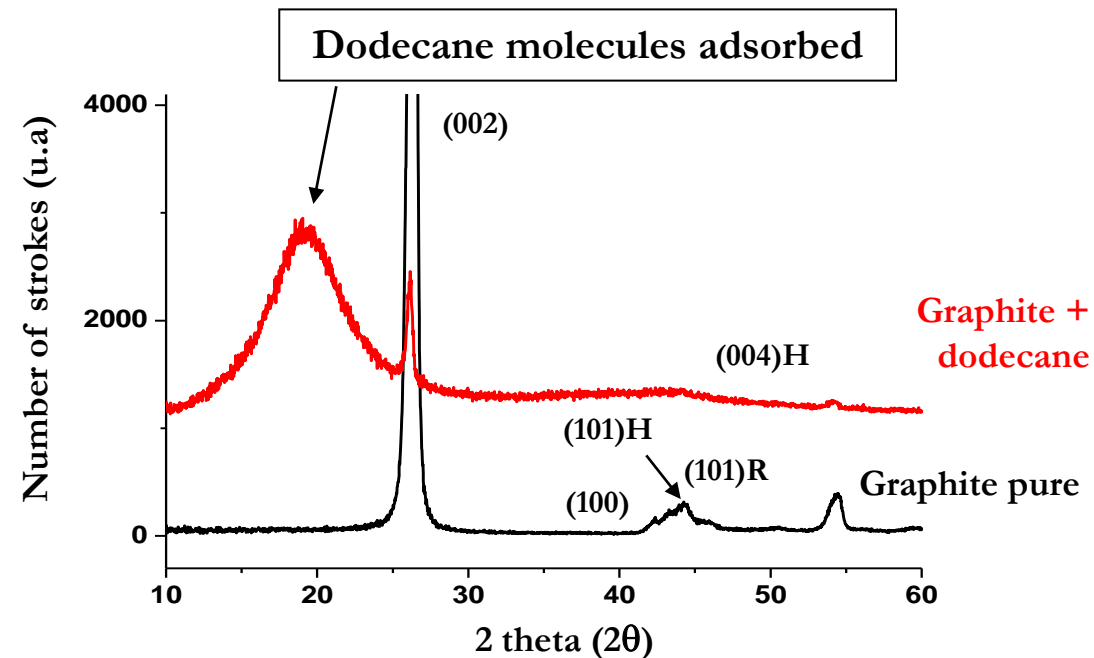
Modification of the friction properties

Diffraction de rayons X

Hypothèses 1 : Intercalation

Under atmospheric pressure

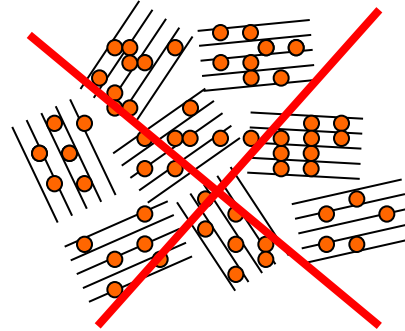
Graphite



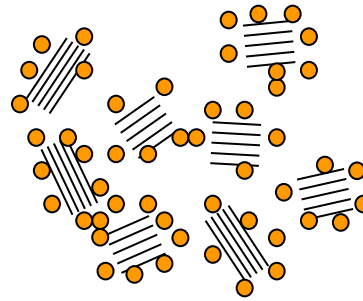
The position of the diffraction peaks corresponding to the interfering spaces are not modified in the presence of the organic liquid.

3 Hypothesis to explain the reduction

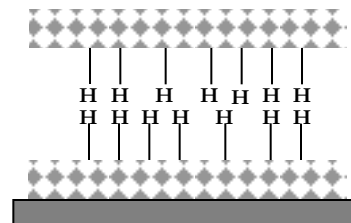
Intercalation of the organic molecules in the van der Waals gaps



Adsorption of organic molecules in the surface



Lubrication by hydrogen



Modification of particles surface energies



Modification of interaction between particles



Modification of particles mobility

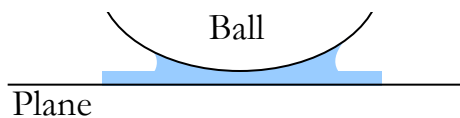


Modification of friction properties

Using different type of molecules

Hypothèses 2 : Adsorption

▲ Friction of liquid

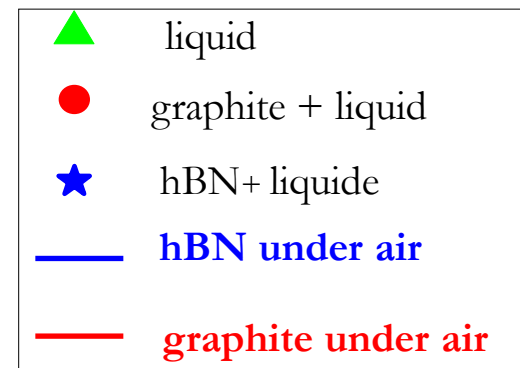
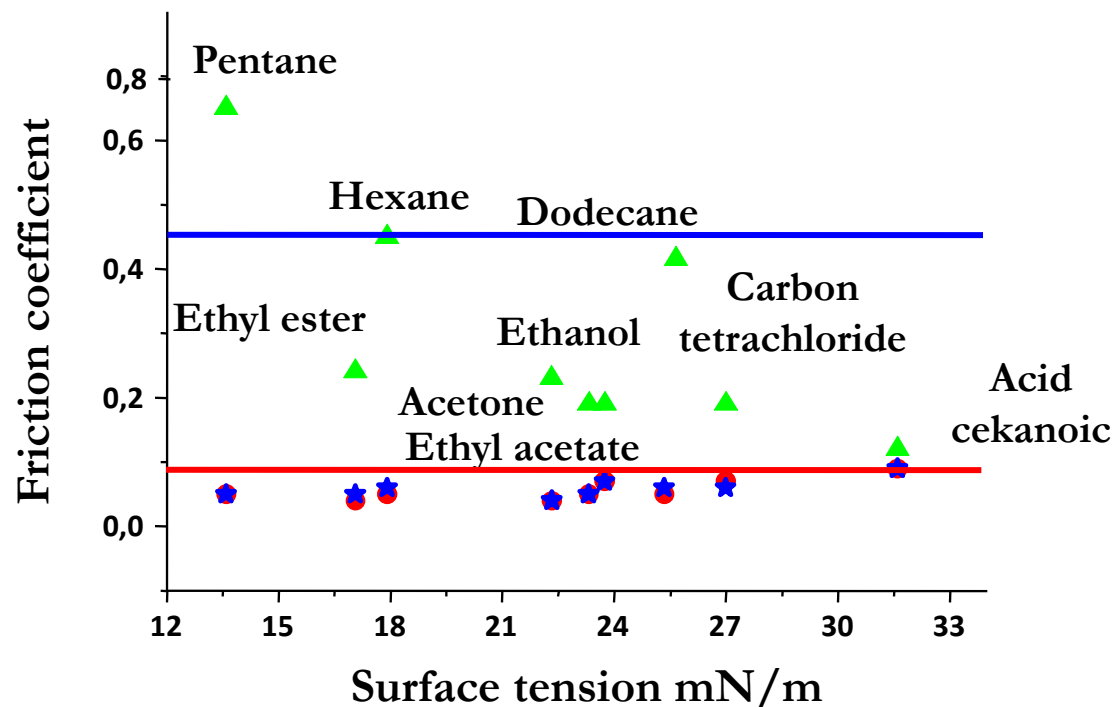


Friction of the particles



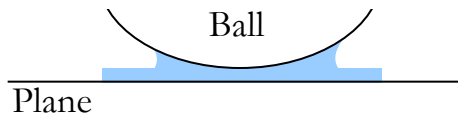
● ★

In the presence of liquid



Hypothèses 3 : Lubrification par l'hydrogène

▲ Friction of liquid

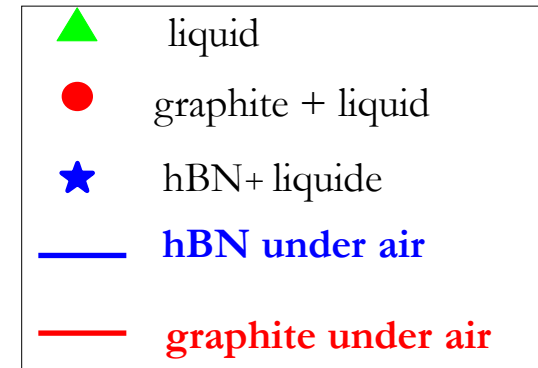
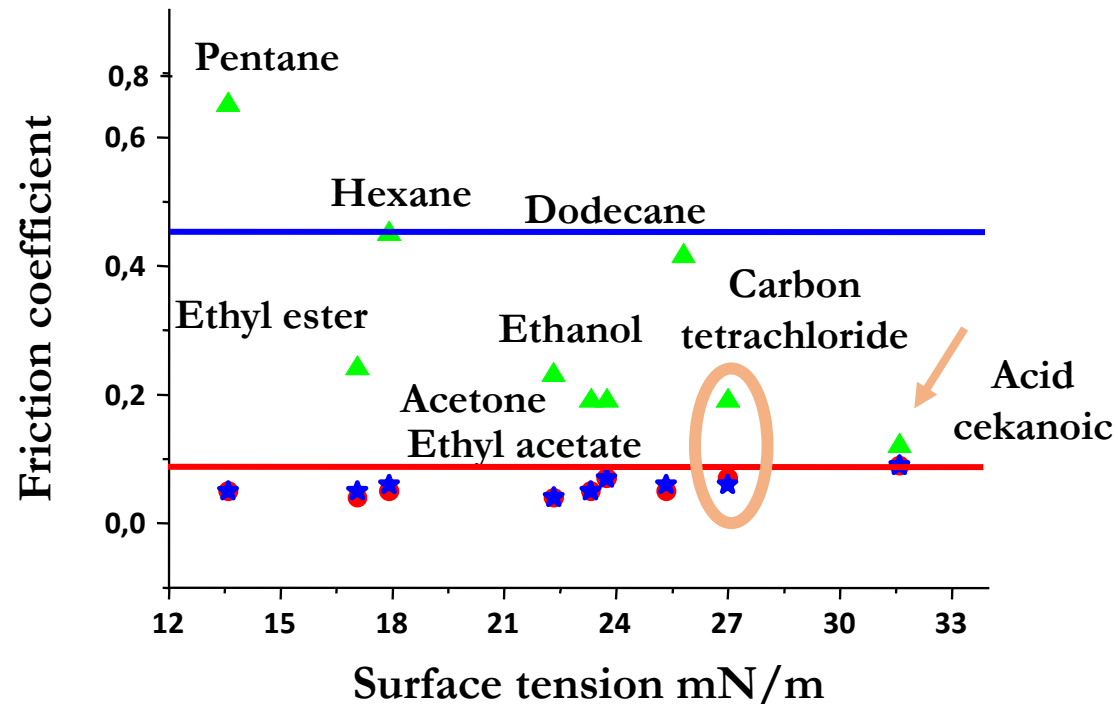


Friction of the particles



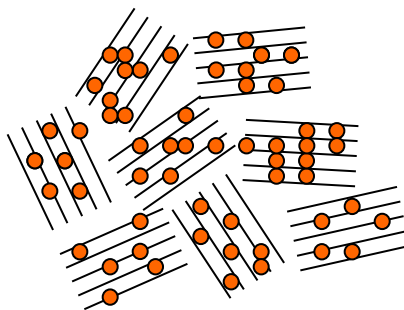
● ★

In the presence of liquid

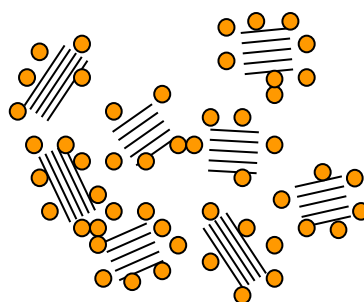


In summary

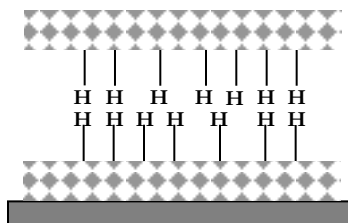
~~Intercalation of the organic molecules in the van der Waals gaps~~



Adsorption of organic molecules in the surface



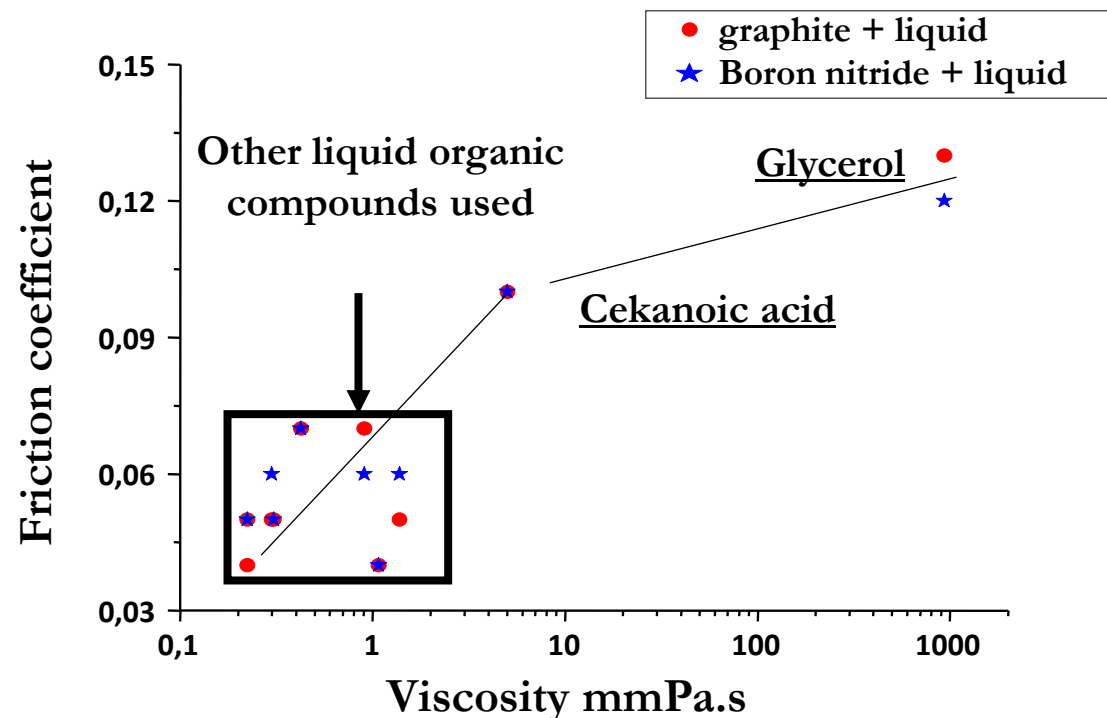
~~Lubrication by hydrogen~~



$$\mu_{\text{graphite} + \text{liquid}} = \mu_{\text{hBN} + \text{liquid}} = 0.05$$

Excepted

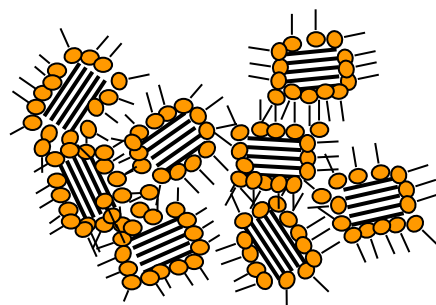
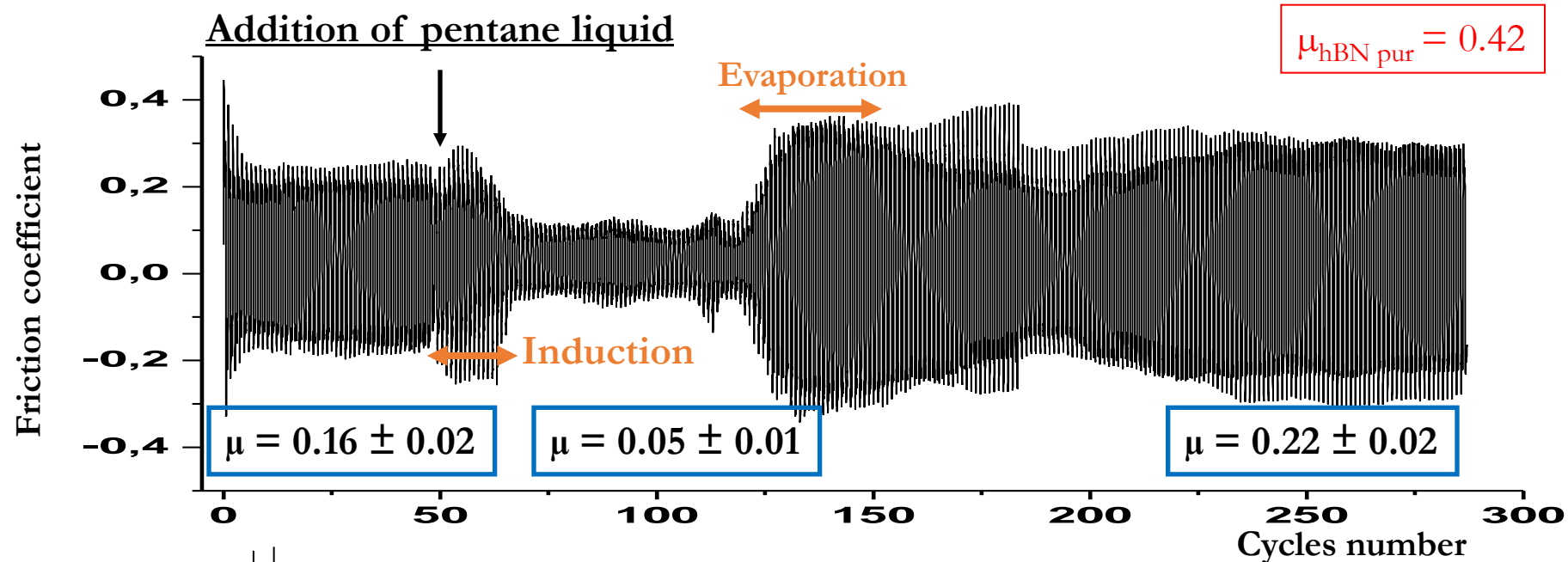
$$\mu_{\text{particles} + \text{CK8}} = 0.10 \quad \mu_{\text{particles} + \text{glycerol}} = 0.12$$



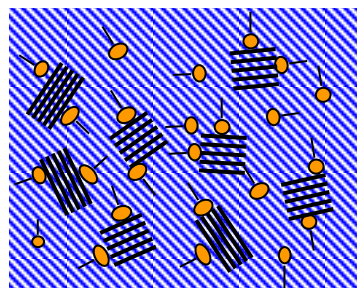
Hypothesis 4 : The influence of the presence of liquid in the contact

Effect of the adsorption and the presence of liquid

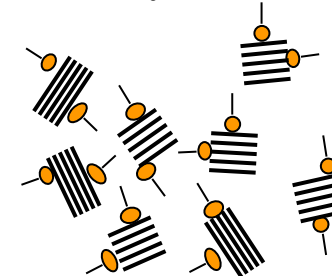
Calculated thickness deposited film 17 Å



Influence of the thickness molecule film deposited



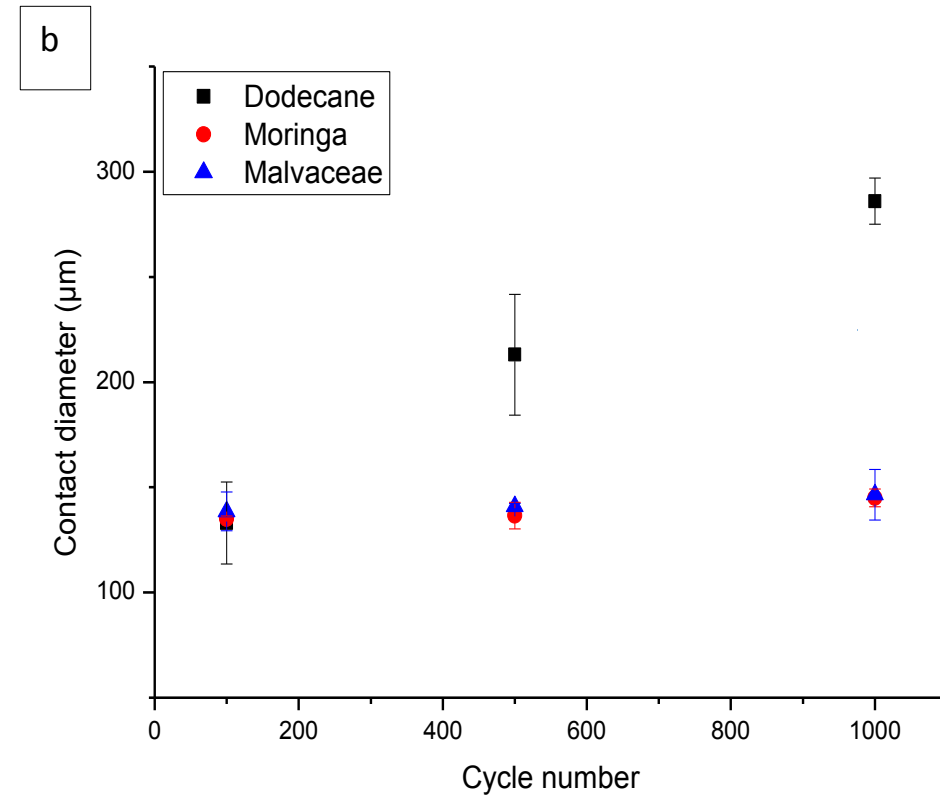
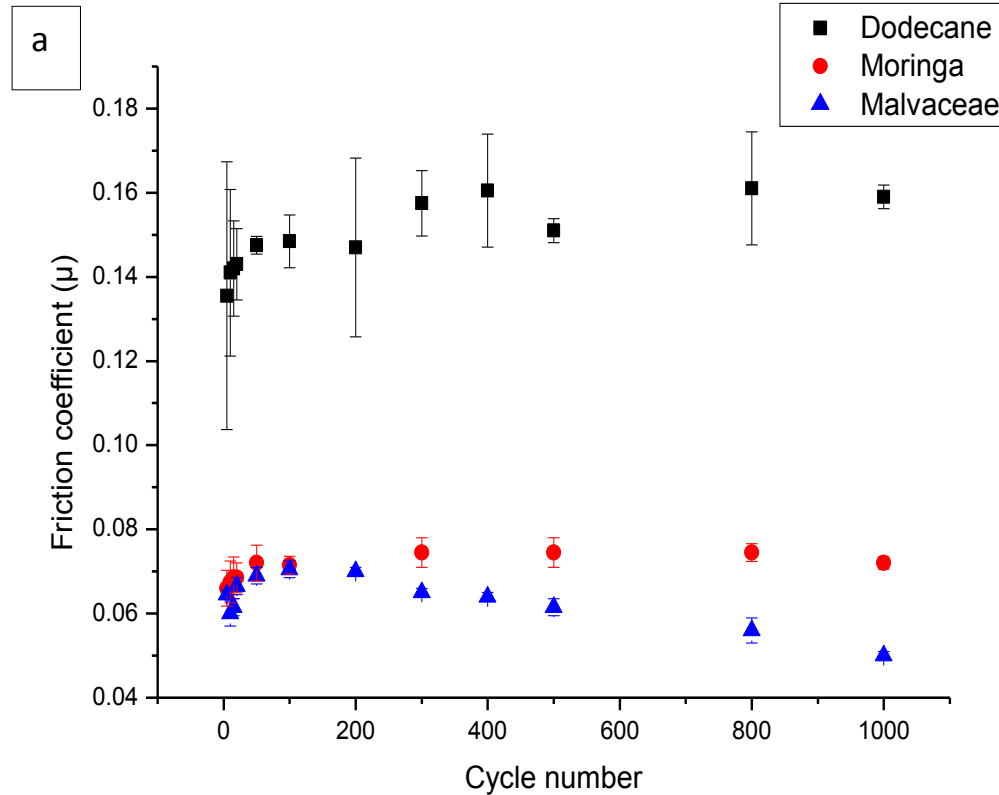
More important action due to the presence of liquid



Organics molecules present after evaporation of pentane

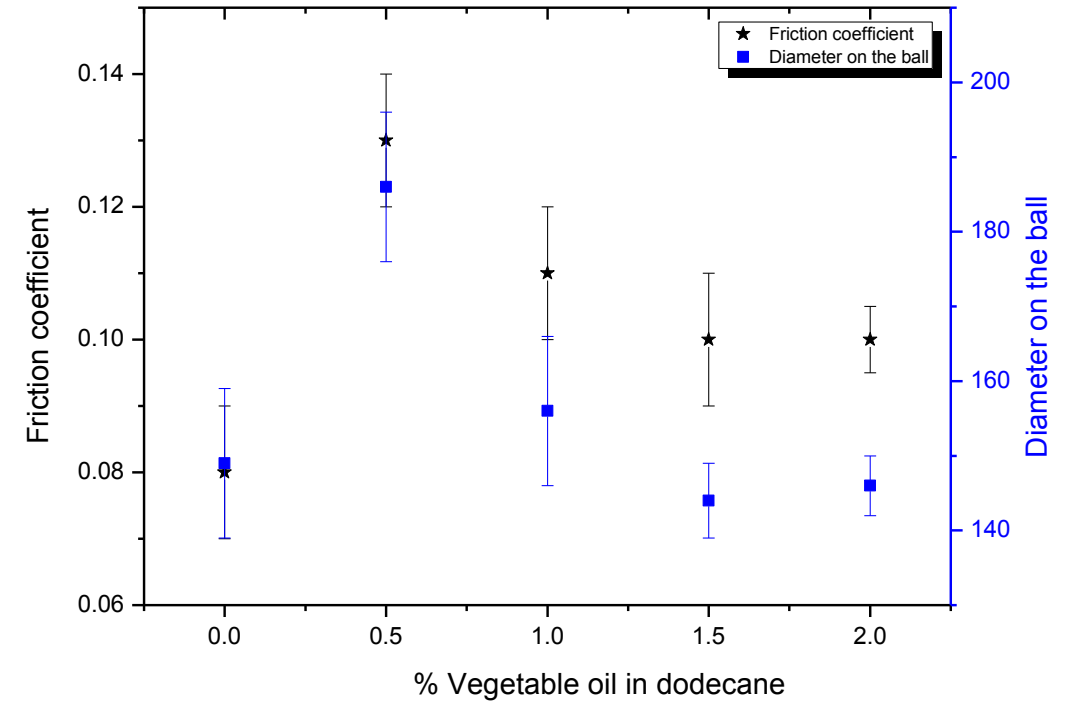
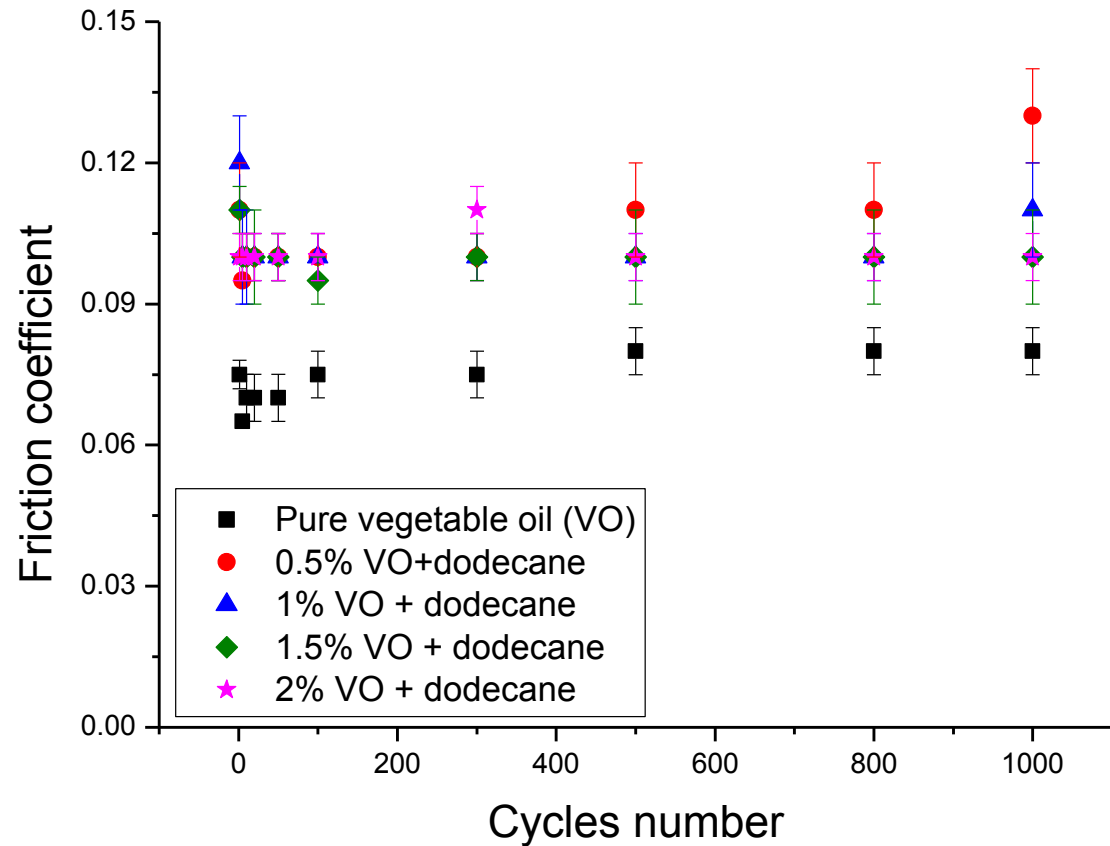
Modification of the liquid properties

Addition of different weight percentage of vegetable oil in dodecane



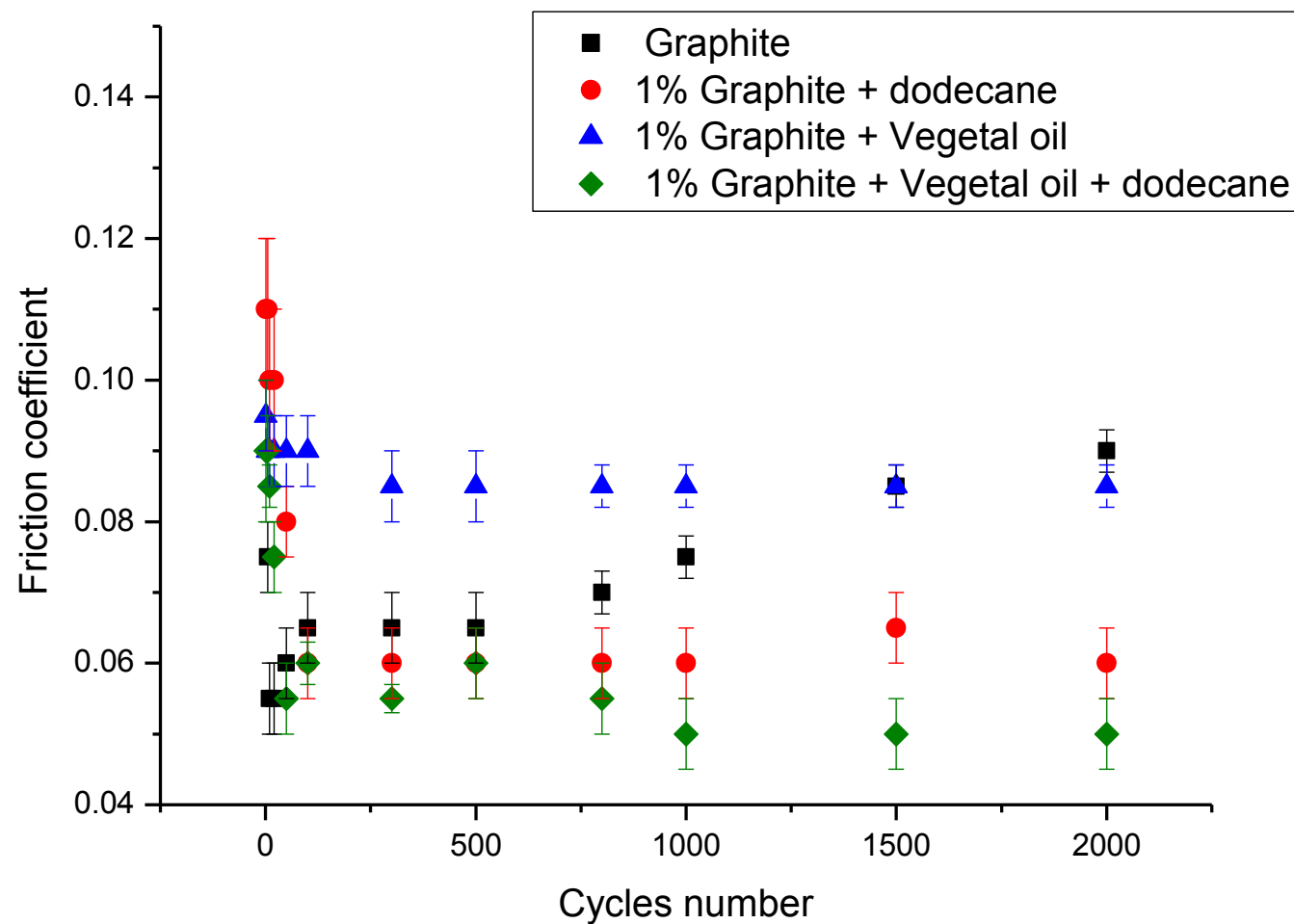
Modification of the liquid properties

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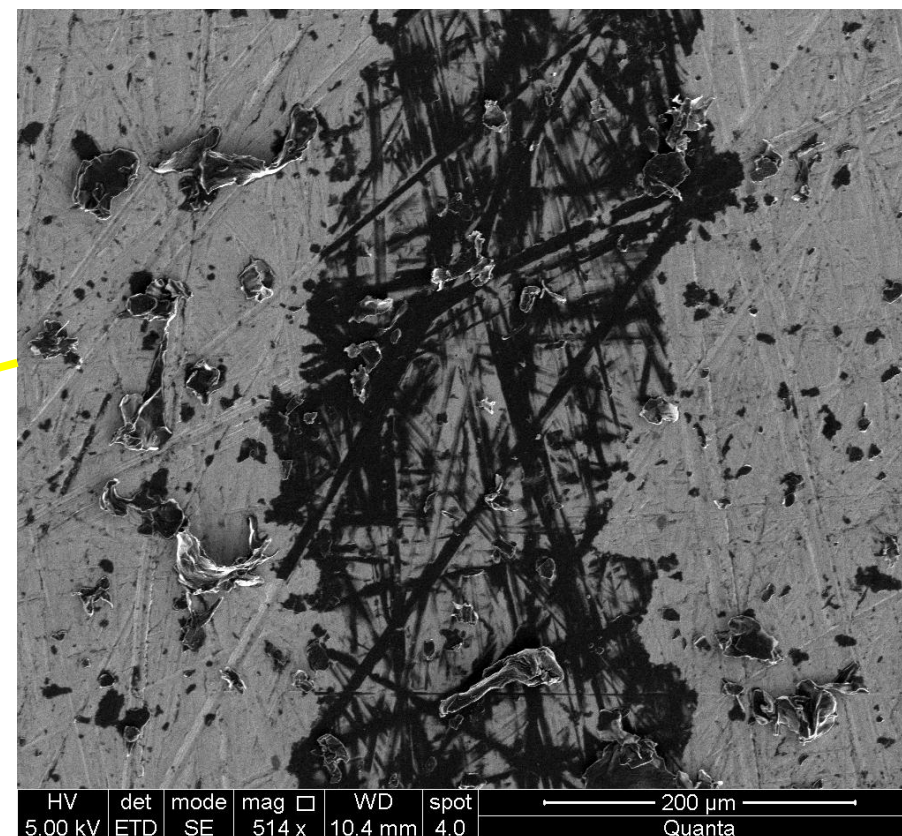
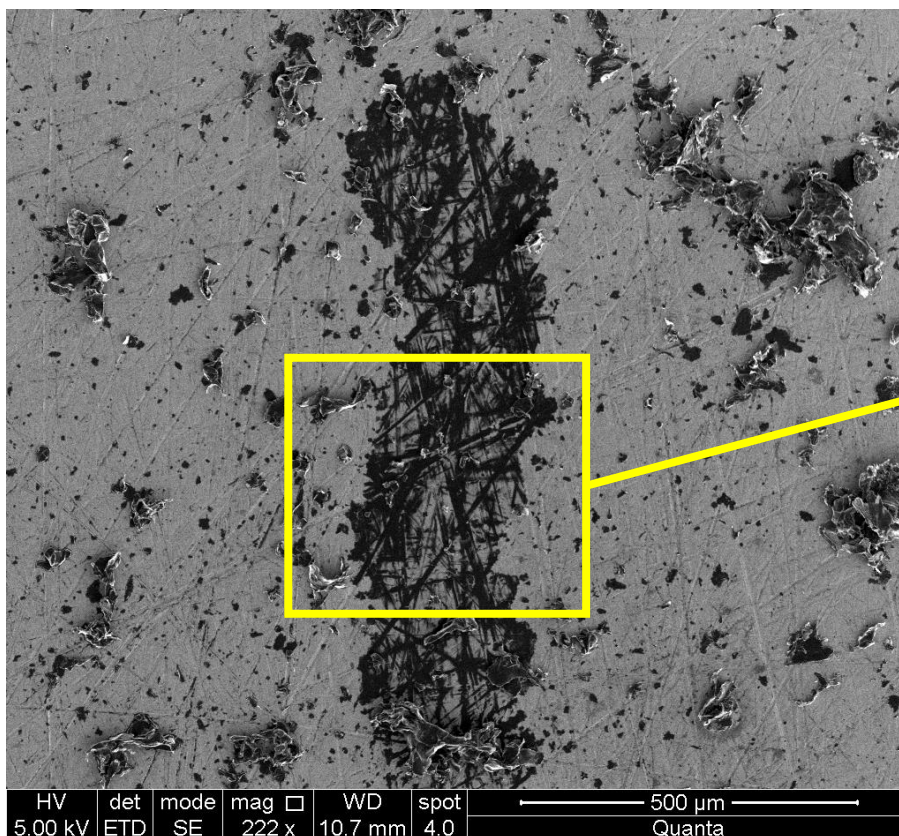
Modification of the liquid properties

Addition of **graphite** at blend of vegetable oil in dodecane



Modification of the liquid properties

Characterization of wear scar formed



conclusion