Tribological properties of vegetable oil added with graphite particles in dodecane

Nadiege Nomede-Martyr, Jacques-Louis Ricard, Rachel Rossi, Yoan Debaud, Philippe Bilas and Philippe Thomas

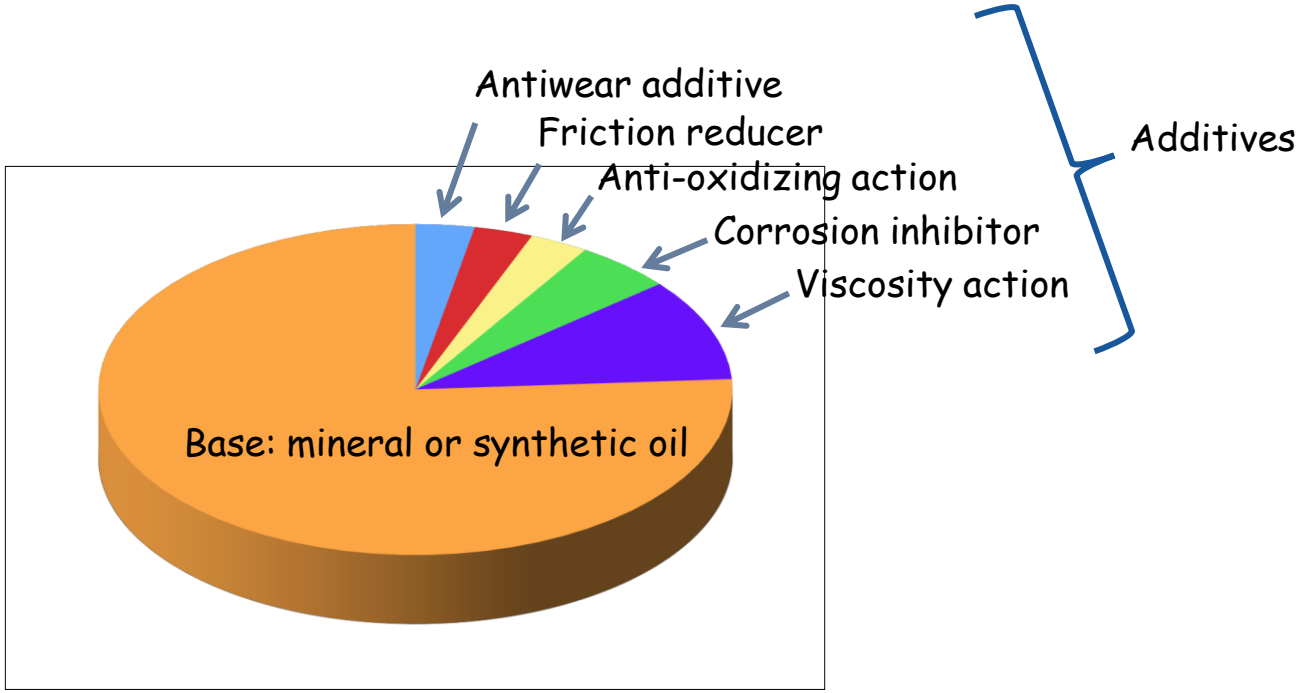
Laboratory GTSI, Université des Antilles, Campus Fouillole, Pointe-a-Pitre, BP 250 97157 ***Guadeloupe***

Outline

* Context of the work
* Tribological experiment device
* Results
* Discussion
* Conclusion and perspective

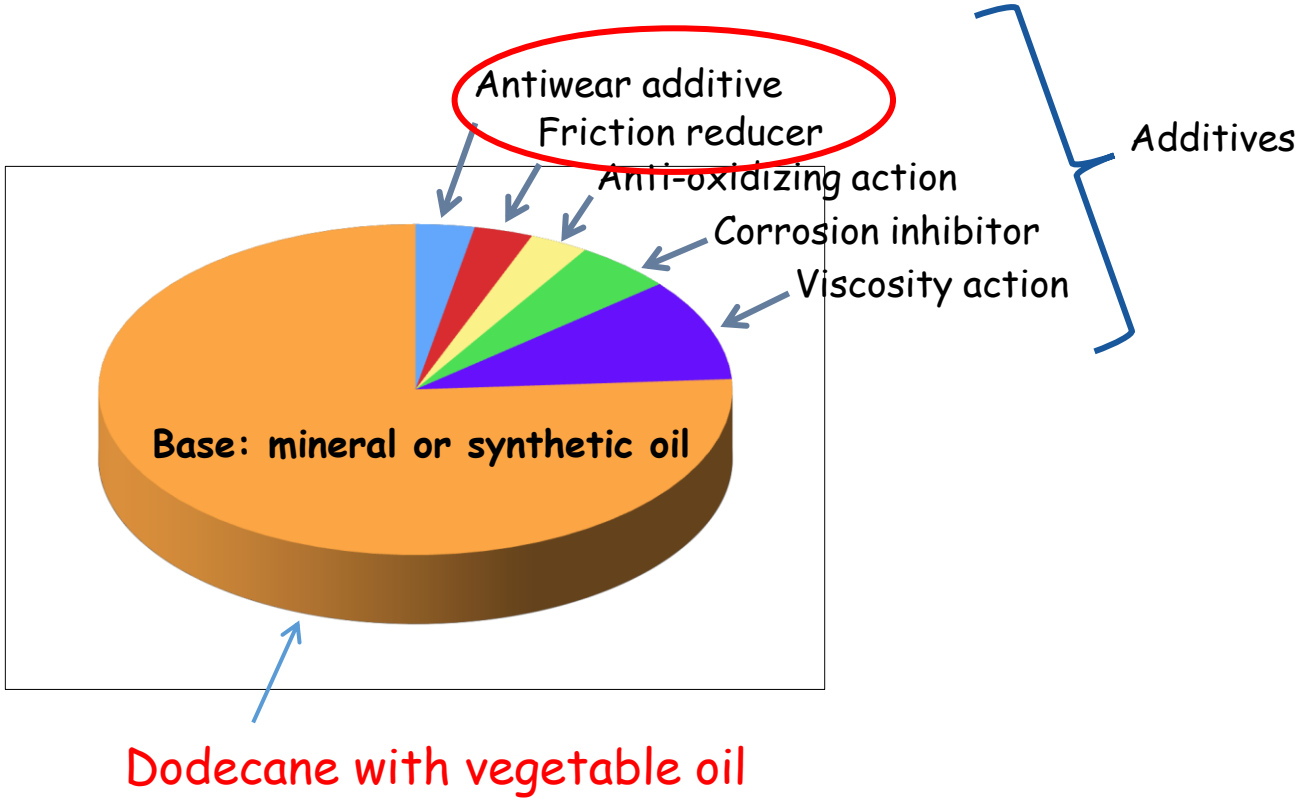
Context: liquid lubrication

Liquid lubricant: base + additives



Context: liquid lubrication

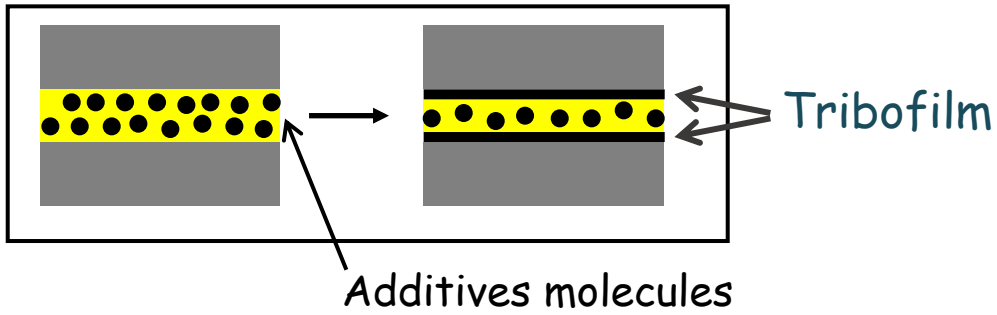
Liquid lubricant: base + additives



Context: liquid lubrication

Conventional additives: Zinc DialkylDithiophosphate (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,…)

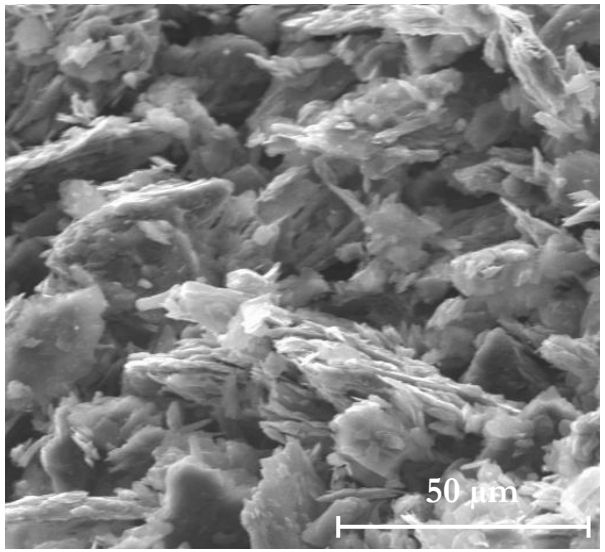
Context: liquid lubrication

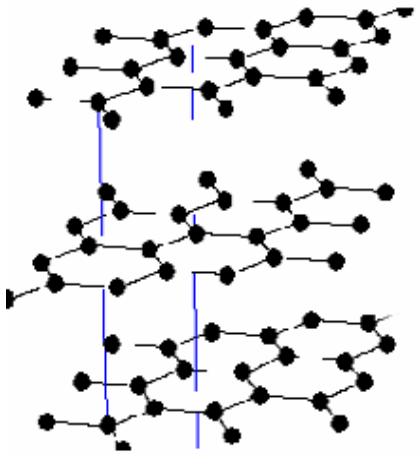
New additives: solid particles subjected to form the tribofilm in the sliding conditions without any chemical reactions with the substrates

Phases are selected according to their intrinsic friction properties

Lamellar structure particles

Graphite





Shape Oval and flattened

Thickness 8 µm

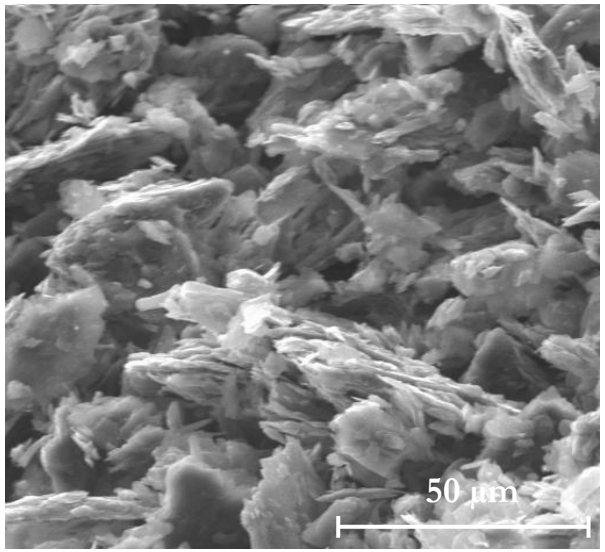
Context: liquid lubrication

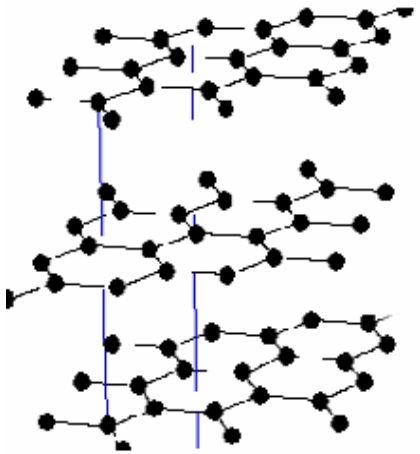
New additives: solid particles subjected to form the tribofilm in the sliding conditions without any chemical reactions with the substrates

Phases are selected according to their intrinsic friction properties

Lamellar structure particles

Graphite



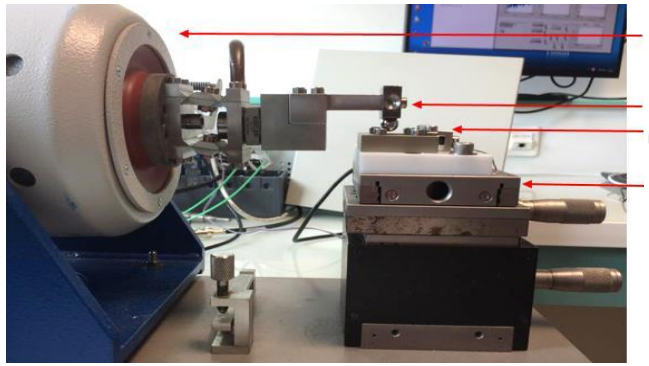


Shape Oval and flattened

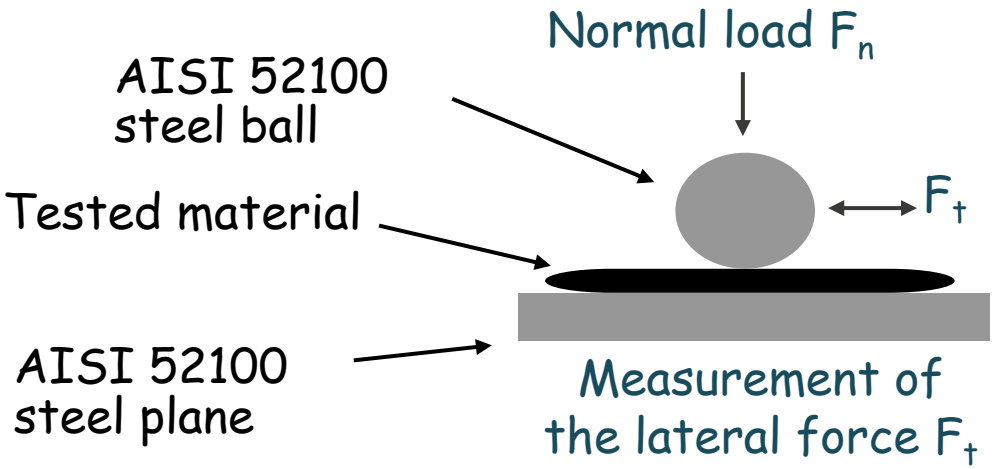
Thickness 8 µm

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

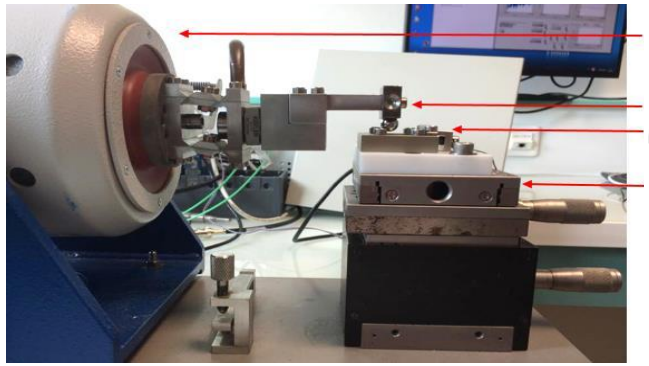
Tribologic experimental device



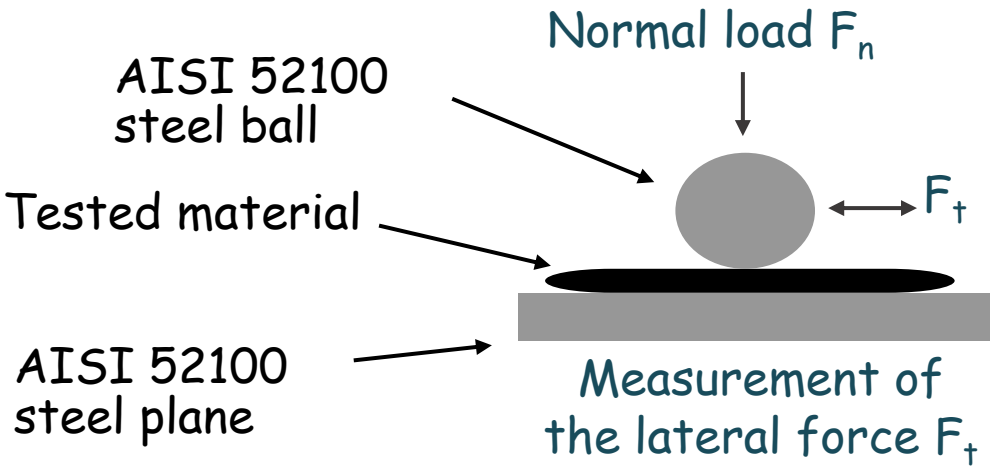
- Normal load: 10 N
- Contact area diameter: 140 μm (Hertz Theory)
- Maximum contact Pressure: 1 GPa
- Sliding speed: 2-3 mm/s

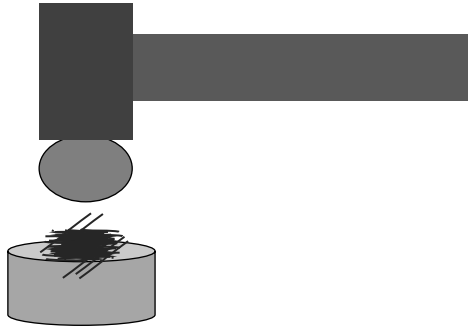


Tribologic experimental

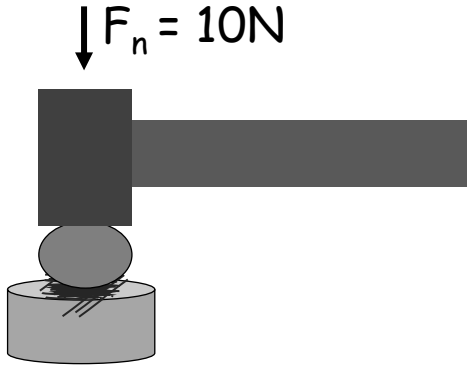


- Normal load: 10 N
- Contact area diameter: 140 μm (Hertz Theory)
- Maximum contact Pressure: 1 GPa
- Sliding speed: 2-3 mm/s

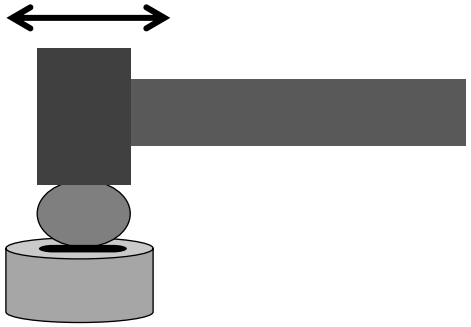




Material deposition

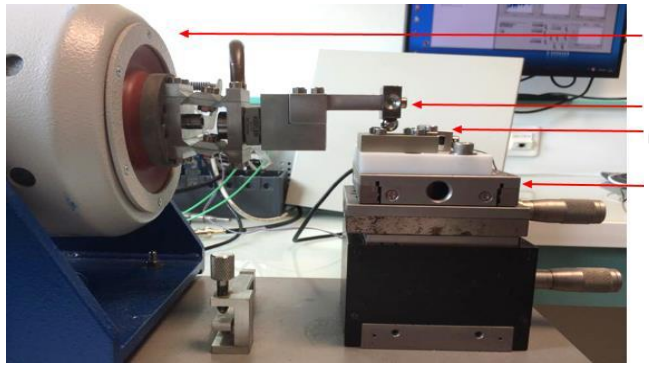


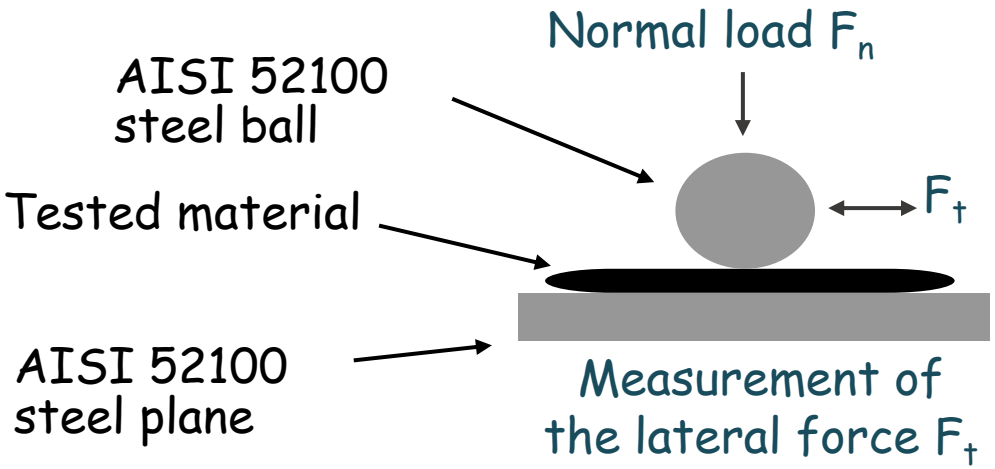
Ball on plane contact
Application of F_n



Back and forth movement of the ball

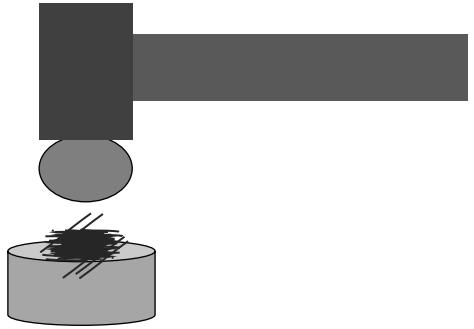
Tribologic experimental



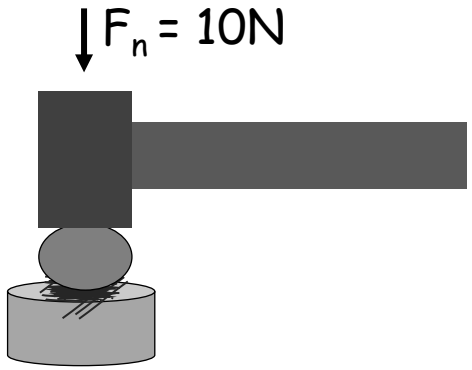


- Normal load: 10 N
- Contact area diameter: 140 μm (Hertz Theory)
- Maximum contact Pressure: 1 GPa
- Sliding speed: 2-3 mm/s

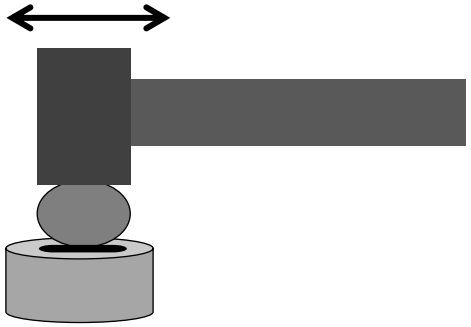
Friction coefficient $\mu = F_t / F_n$



Material deposition



Ball on plane contact
Application of F_n

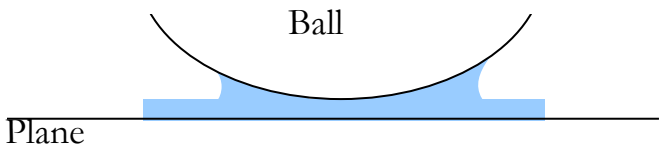


Back and forth
movement of the ball

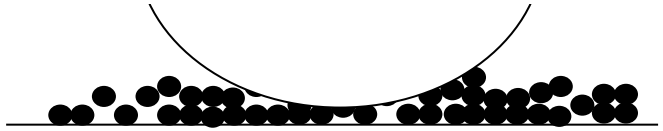
Tribologic experimental

Experimental conditions

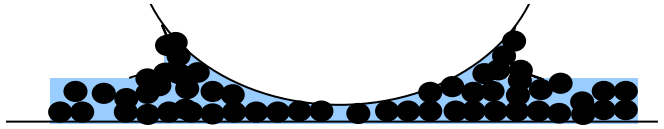
Frition of liquid



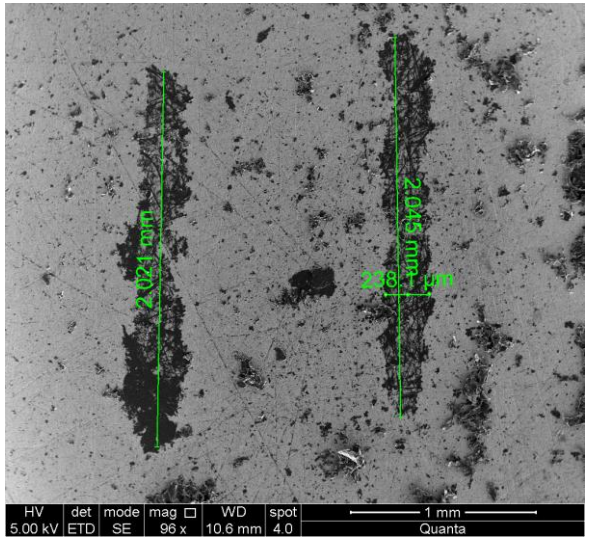
Friction of pure particles



Friction at addition of dodecane
Or
Friction of liquid/particles mixture



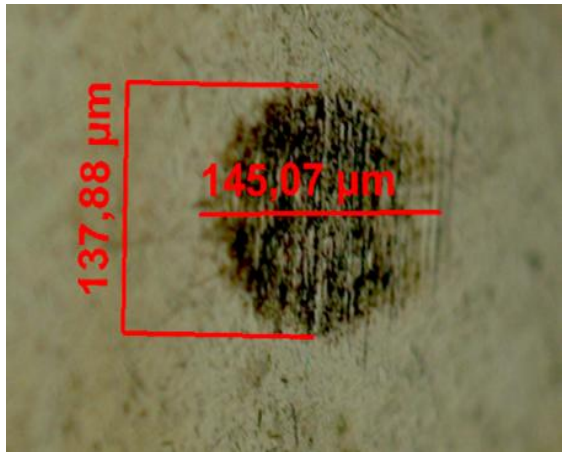
On the plane



Analysis of the tribofilms

- SEM
- Raman spectroscopy

On the ball

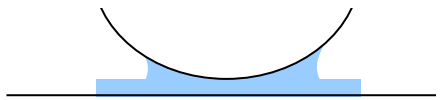


Measurement of contact area diameter

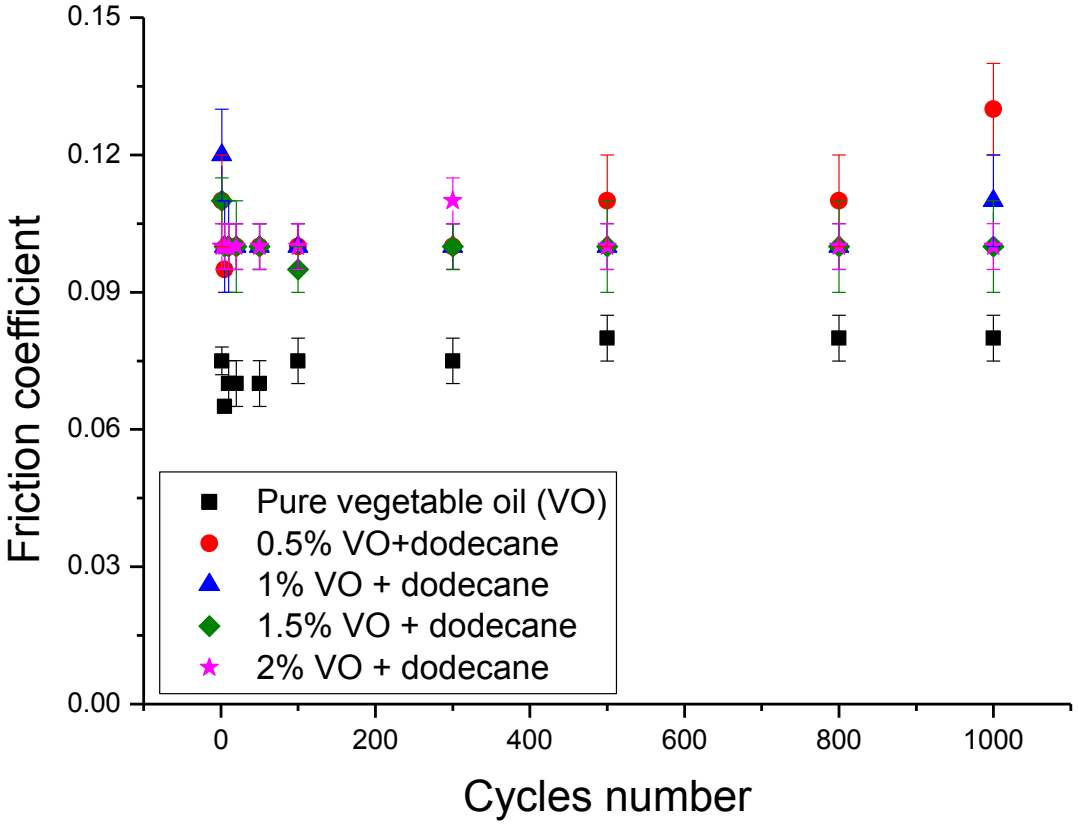
Hertz's Theory
140 µm

Results

Addition of different weight percentages of vegetable oil in dodecane



$\mu_{Dodecane} = 0.4$



Stable friction coefficients

Weak VO w%

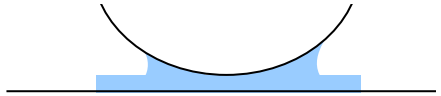
The friction coefficients of mixtures are higher than the coefficients obtained for pure VO oil

But

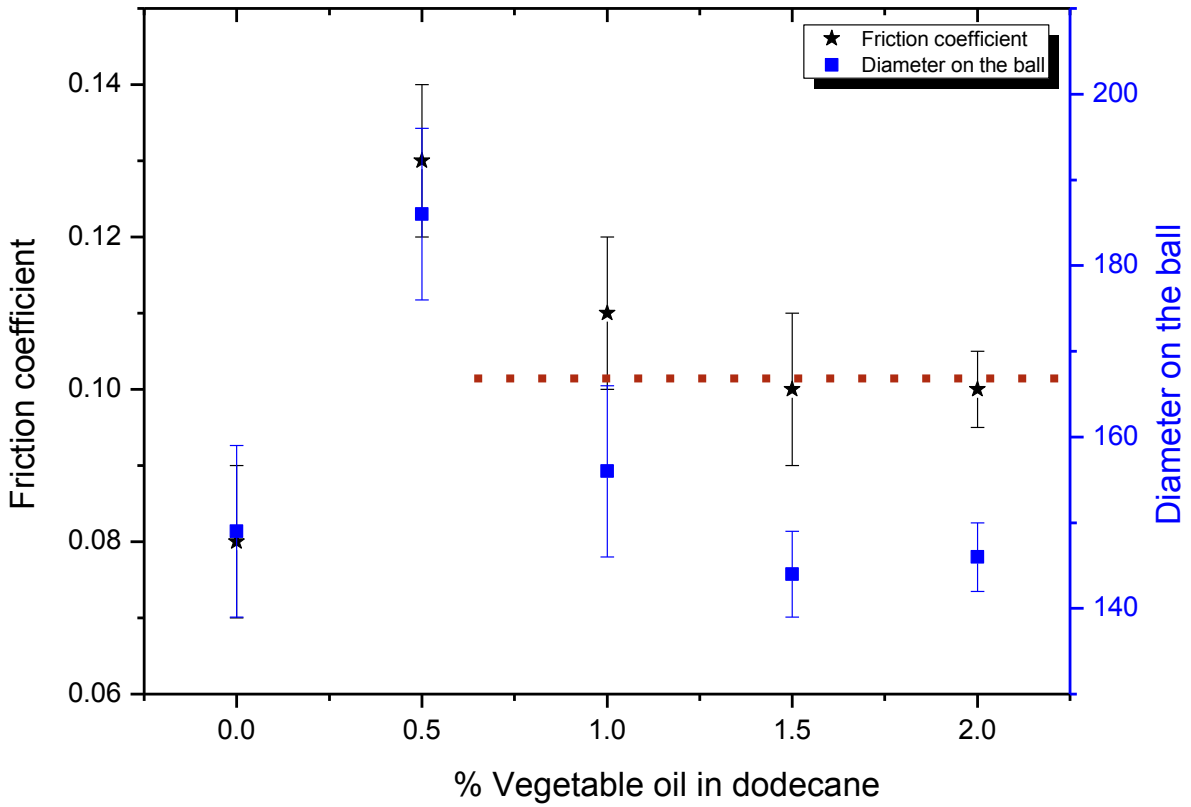
remain very lower than the dodecane friction coefficient

Results

Addition of different weight percentages of vegetable oil in dodecane

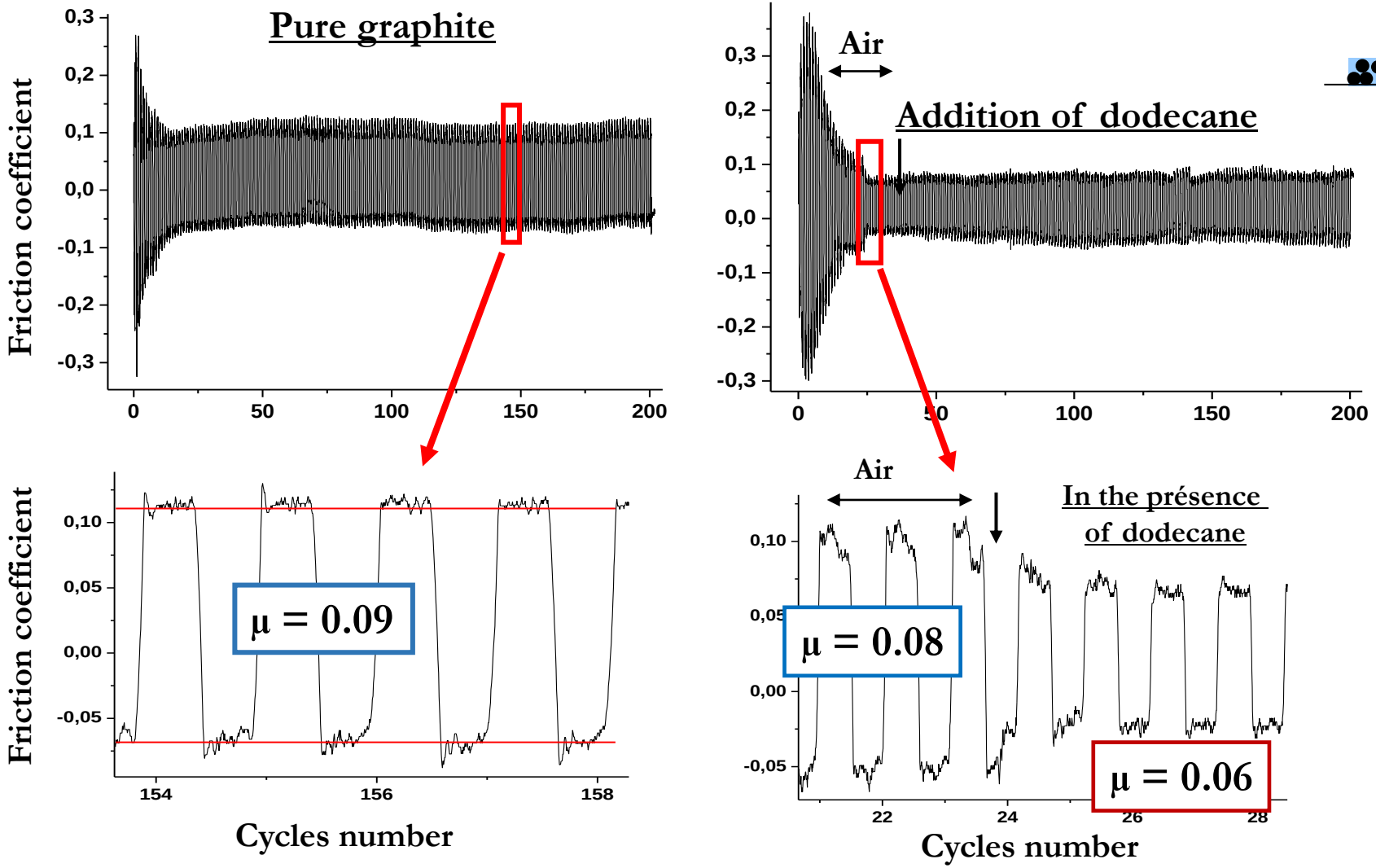


1000 cycles



Mixtures of dodecane/vegetable oils present optimized tribological performances

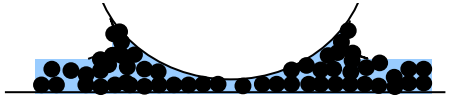
Friction properties of graphite/dodecane

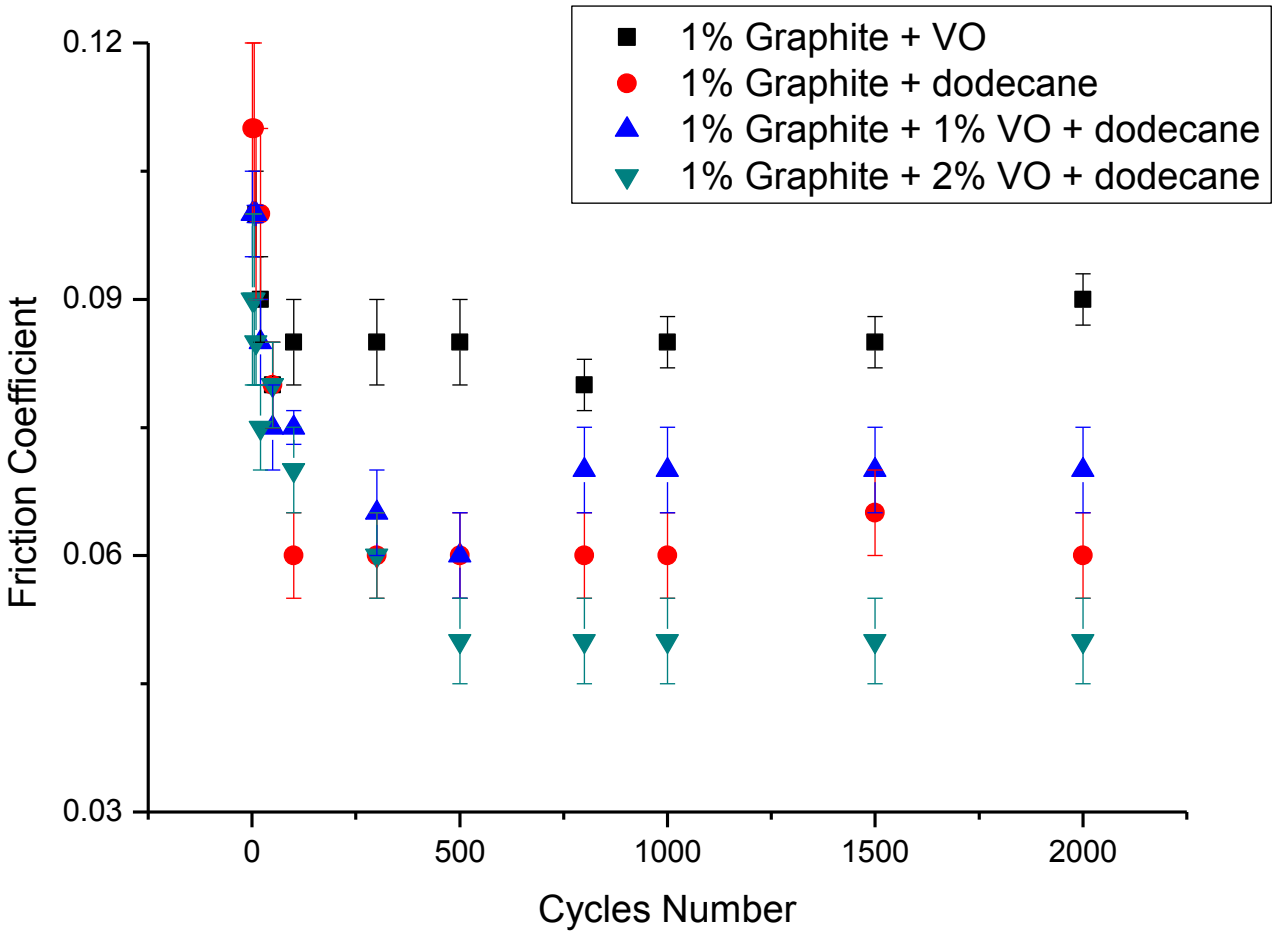


Important and drastic reduction of the friction coefficient in the presence of liquid

Results

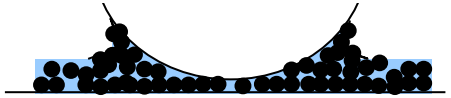
Addition of graphite in vegetable oil/dodecane blends

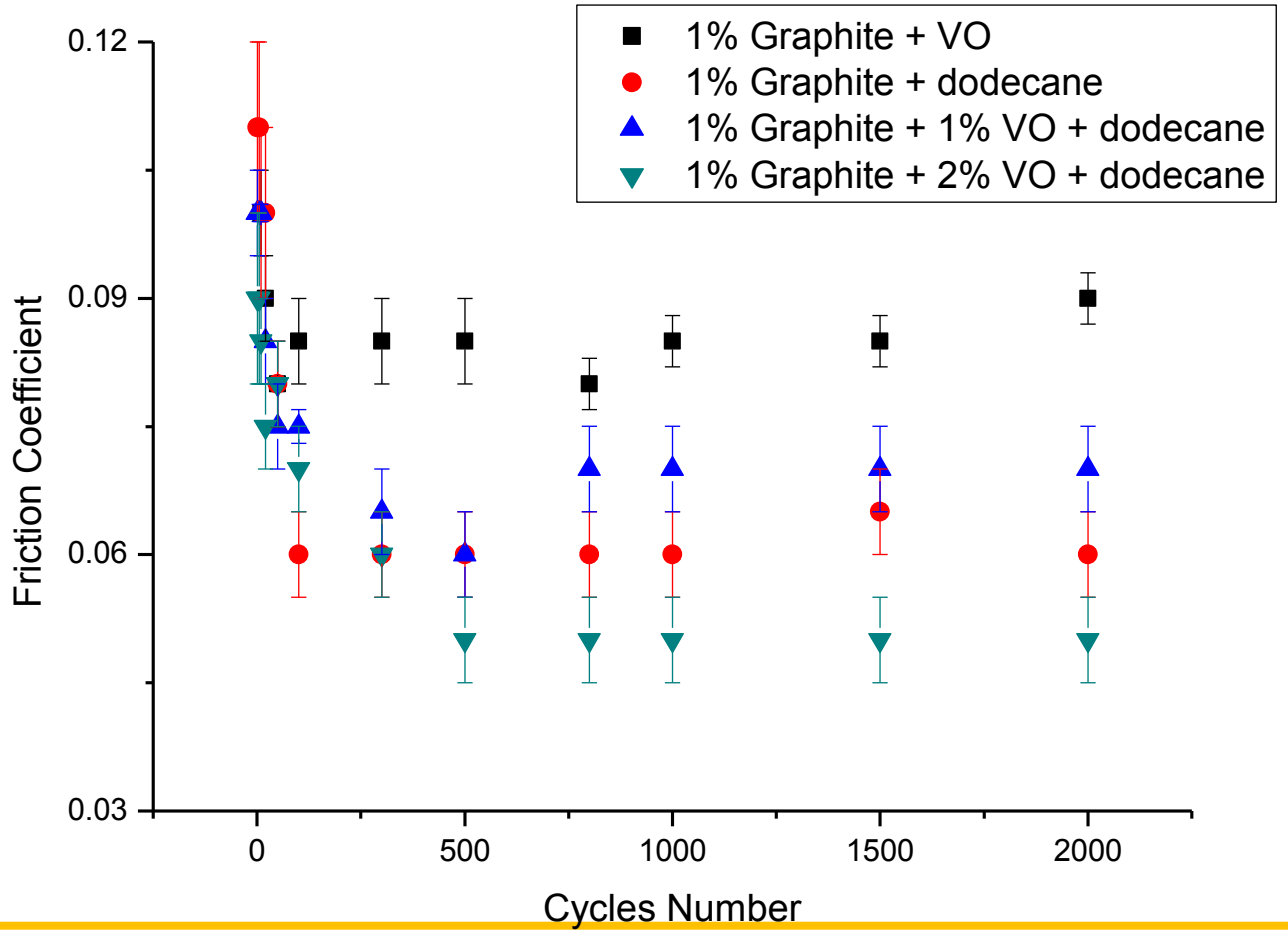




Results

Addition of graphite at blend of vegetable oil/dodecane

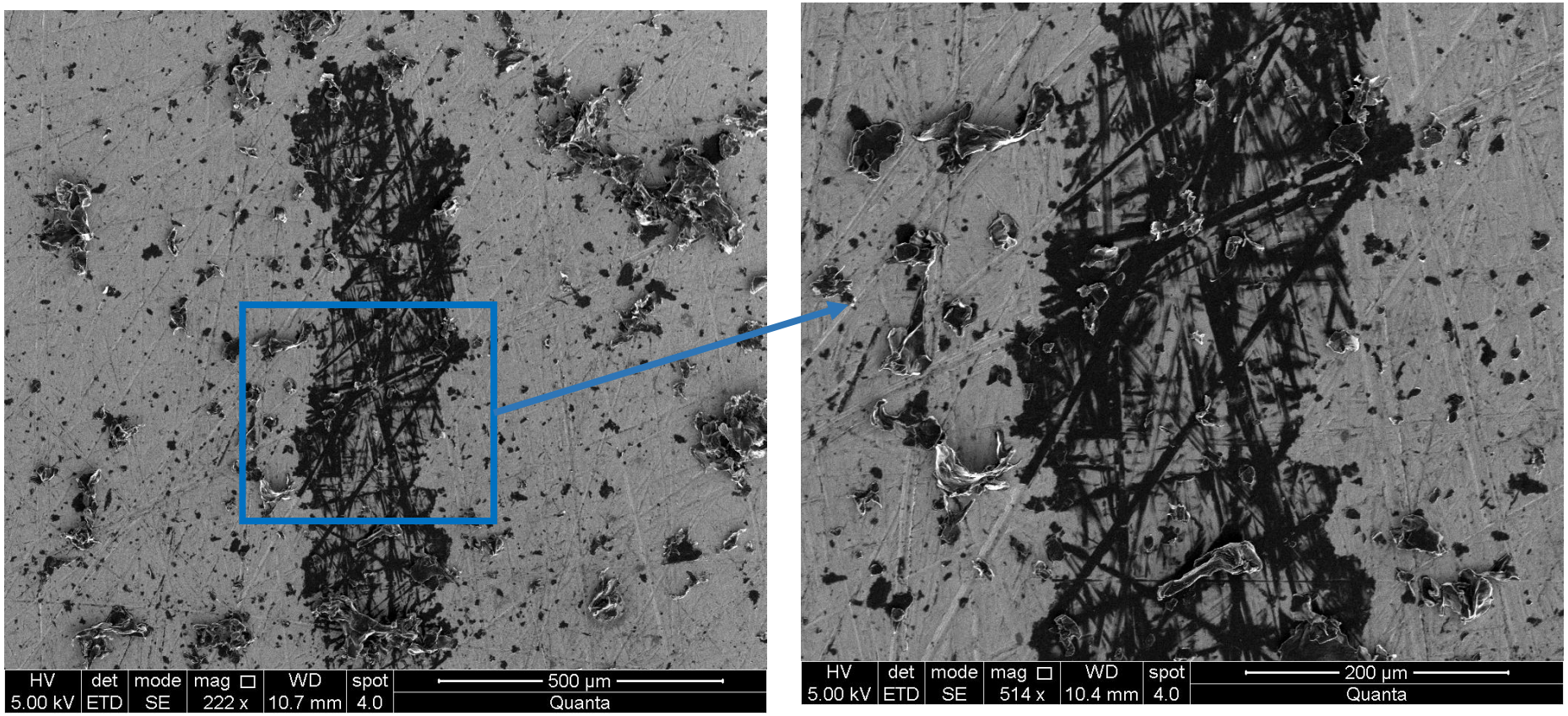




Excellent influence of the presence of vegetable oil in dodecane à 2 w% on the friction properties

Results

Characterization of wear scars

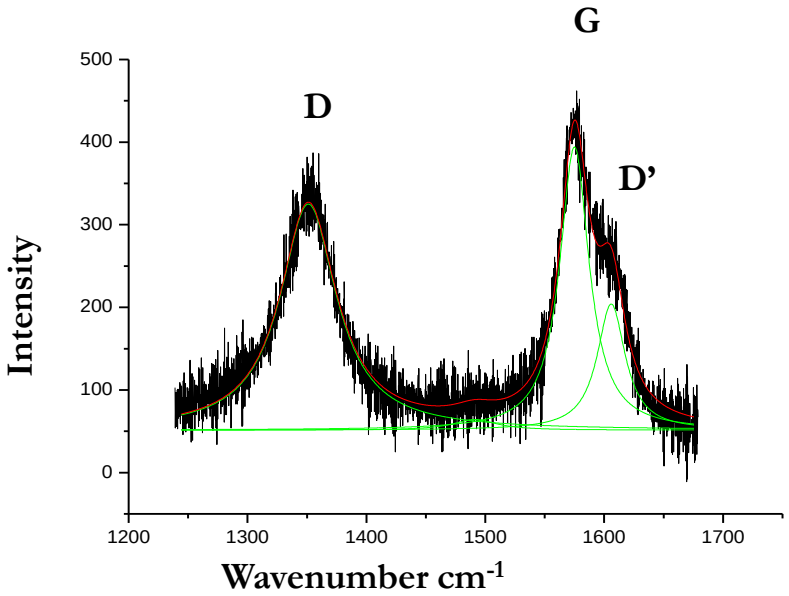


Excellent antiwear properties of the tribofilm

Discussion

Previous studies

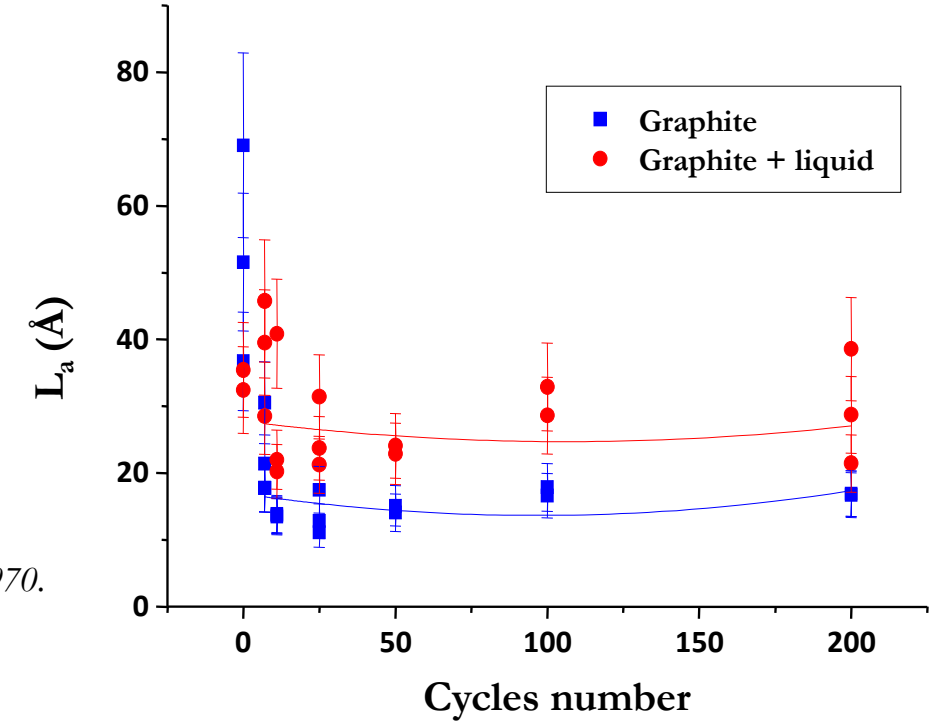
Raman spectroscopy



$$L_a = C(\lambda)\frac{I_{G_{1580cm^{-1}}}}{I_{D_{1350cm^{-1}}}}$$

$$C(\lambda = 532nm) = 44$$

F. Tuinstra et al, J. Chemical Physic, 53 :1126, 1970.



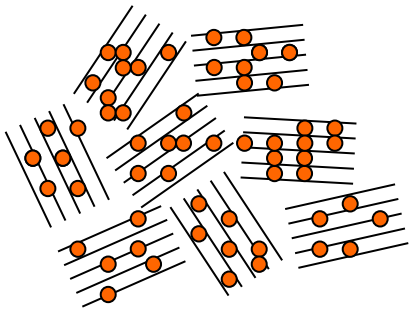
Weak mechanical constraints in the presence of dodecane inducing weak modification of particles structure

PhD study's N. Nomede-Martyr

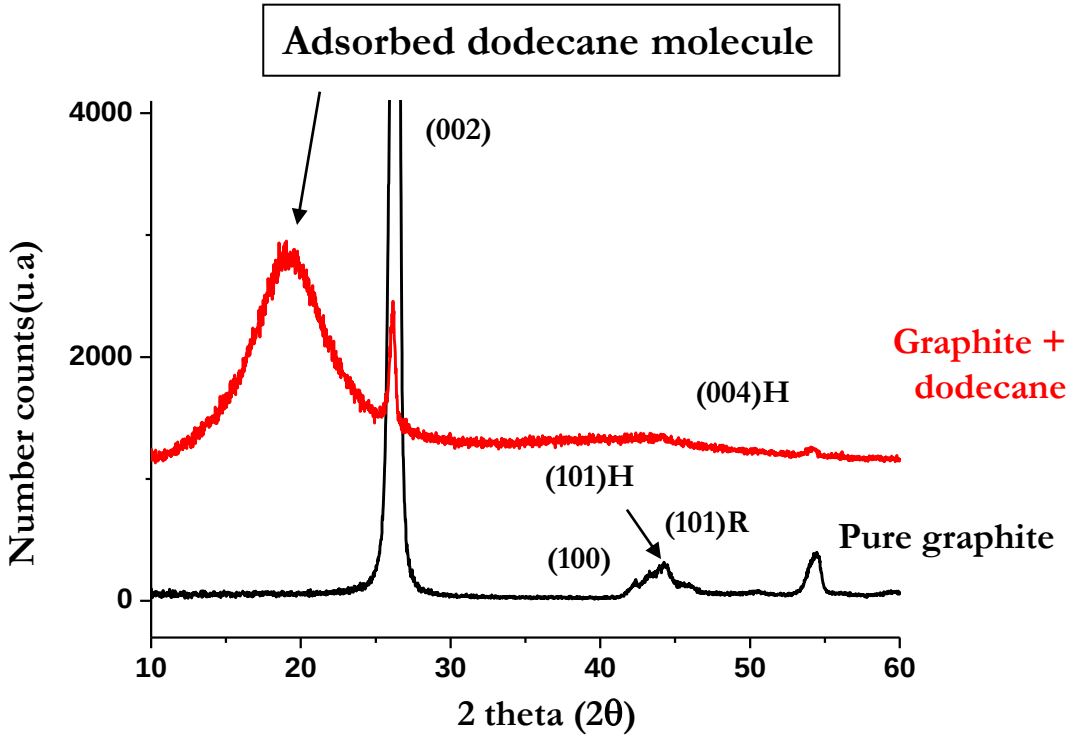
Discussion

Previous studies

Intercalation of the organic molecules in the van der Waals gaps



X-rays Diffraction

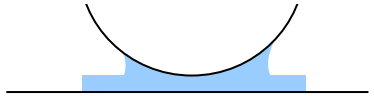


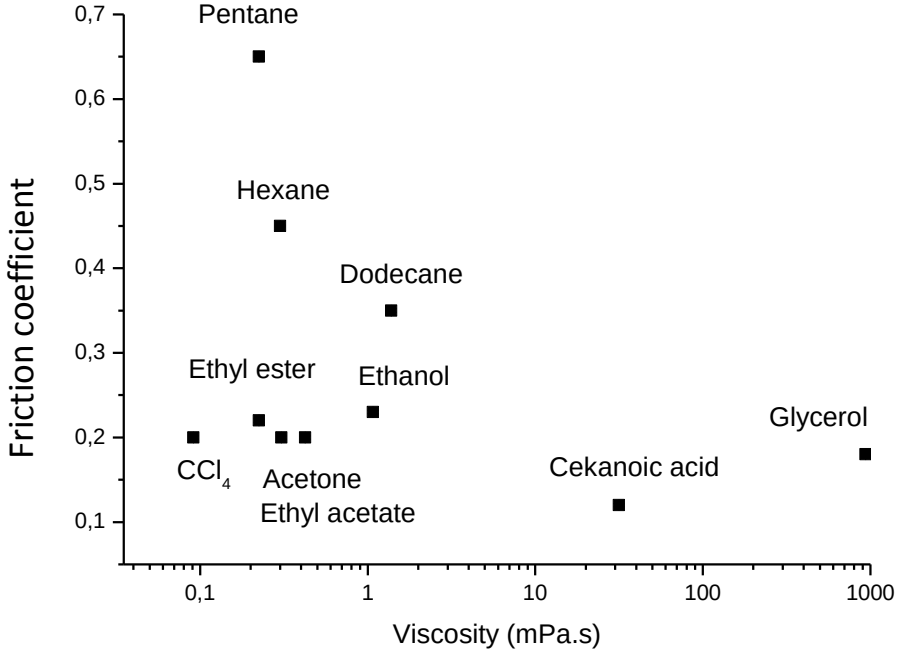
No intercalation because the position of the diffraction peaks corresponding to interlayers spaces are not modified in the presence of dodecane

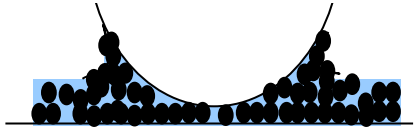
PhD study's N. Nomede-Martyr

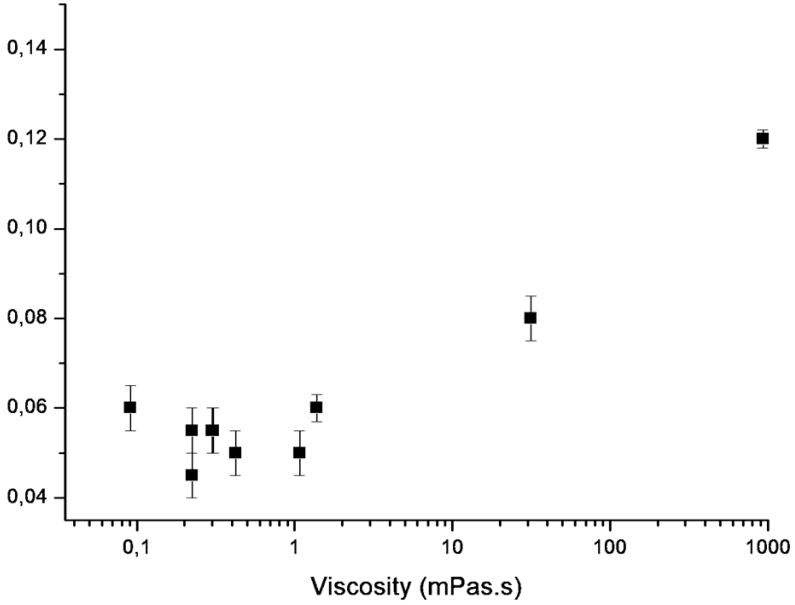
Discussion

Previous studies







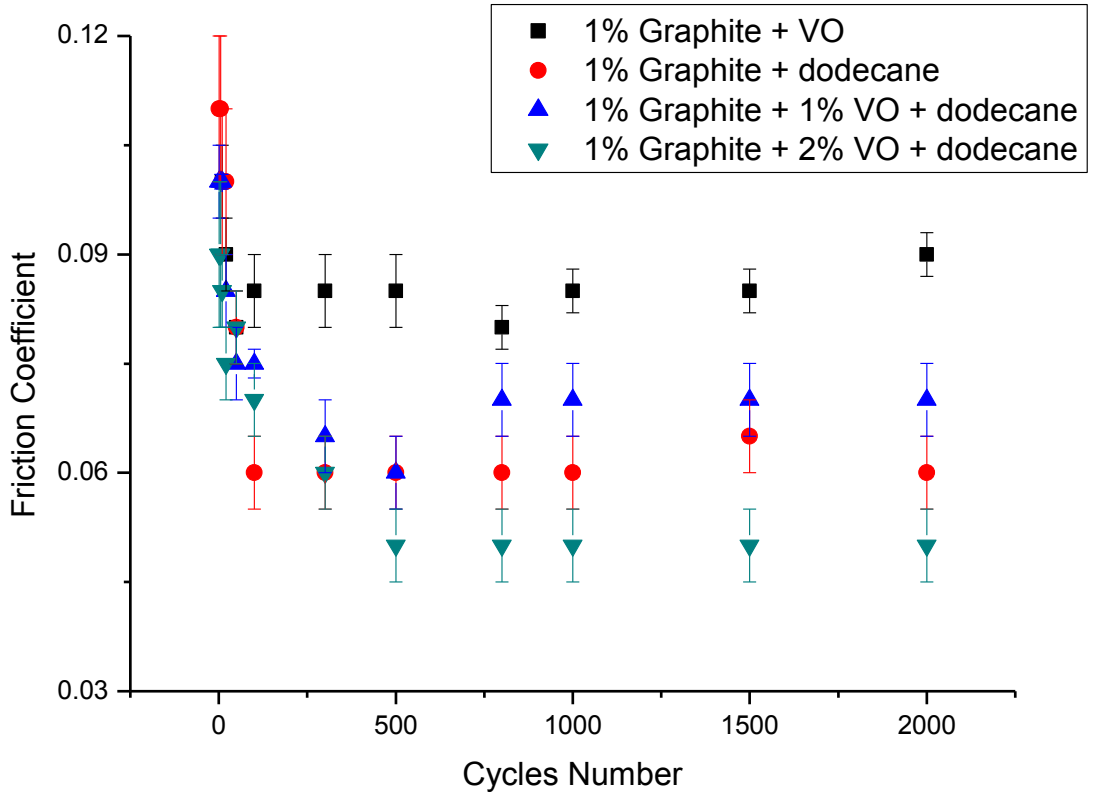


Influence of the viscosity on the friction property of the particles

PhD study's N. Nomede-Martyr

Discussion

Results obtained



Viscosity

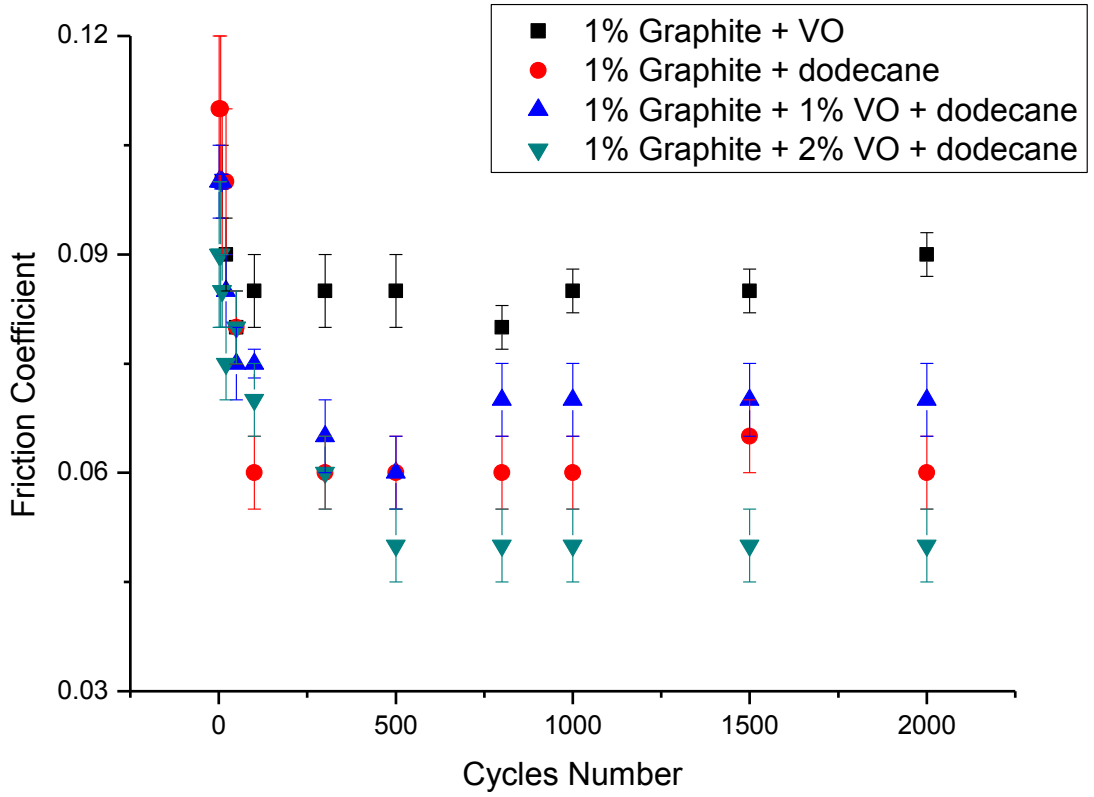
$\eta_{\text{pure VO}} \approx 72$ mPa.s

$\eta_{\mathbf{1w\%VO}+\text{dodecane}} \approx 1.8$ mPa.s

$\eta_{\mathbf{2w\%VO}+\text{dodecane}} \approx$ mPa.s

Discussion

Results obtained



Viscosity

$\eta_{\text{pure VO}} = 72$ mPa.s

$\eta_{\mathbf{1w\%VO}+\text{dodecane}} =$ mPa.s

$\eta_{\mathbf{2w\%VO}+\text{dodecane}} =$ mPa.s

Investigations in progress

Viscosiy parameter is not sufficient to explain the friction reduction process

Conclusion and perspective

- The presence of liquid in the sliding contact improves the friction properties of particles

The reduction is due to the presence of both liquid and particles in the sliding contact

- The presence of vegetable oil as additive at weak percentage decrease the friction coefficient of dodecane
- Excellent results are obtained with mixtures solid/liquid at 2 w% of VO
  - **Reduction of mechanical constraints undergone by particles in the presence of liquid**
  - **No intercalation of organic molecules**
  - **Viscosity parameter is not to explain this reduction**

We work with other type of solid particles and different type of vegetable oils.

Thanks a lot for your attention!

nadiege.nomede-martyr@univ-antilles.fr

ACKNOWLEDGEMENTS: The authors acknowledge the Fonds Européens de Développement Régional (FEDER) for their financial supports.