A DMA operating at 200 ^{o}C for the analysis of engine exhaust nanoparticles

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SUREAL-23

Motivation for 200 ^{o}C DMA

Collaboration with Konstandopulos and colleagues at Thesaloniki (**poster TP-49**):

Because gas cooling often leads to condensation artifacts, the Greek group proposes operating the DMA near car exhaust gas temperature to simplify exhaust sampling procedure (less dilution requirements). Further dilution due to sheath air

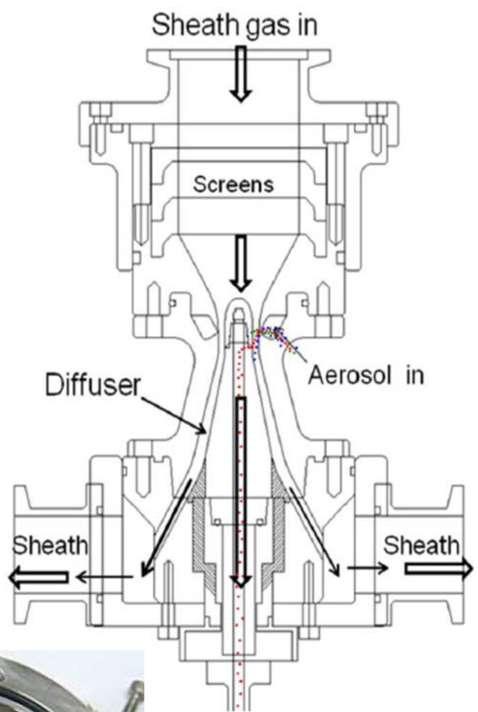
Other conceivable applications to materials synthesis

Parallel plate DMA would additionally freeze rapid kinetics prior to sampling

Outline for 200 ^{o}C DMA

1. Half-mini DMA
2. Half-mini DMA high temperature configuration
3. Change of materials at the DMA outlet
4. Thermal fatigue of PEEK insulator and loss of resolution
5. Material change of the DMA centering insulator
6. Results
7. Conclusions
8. Acknowledgements

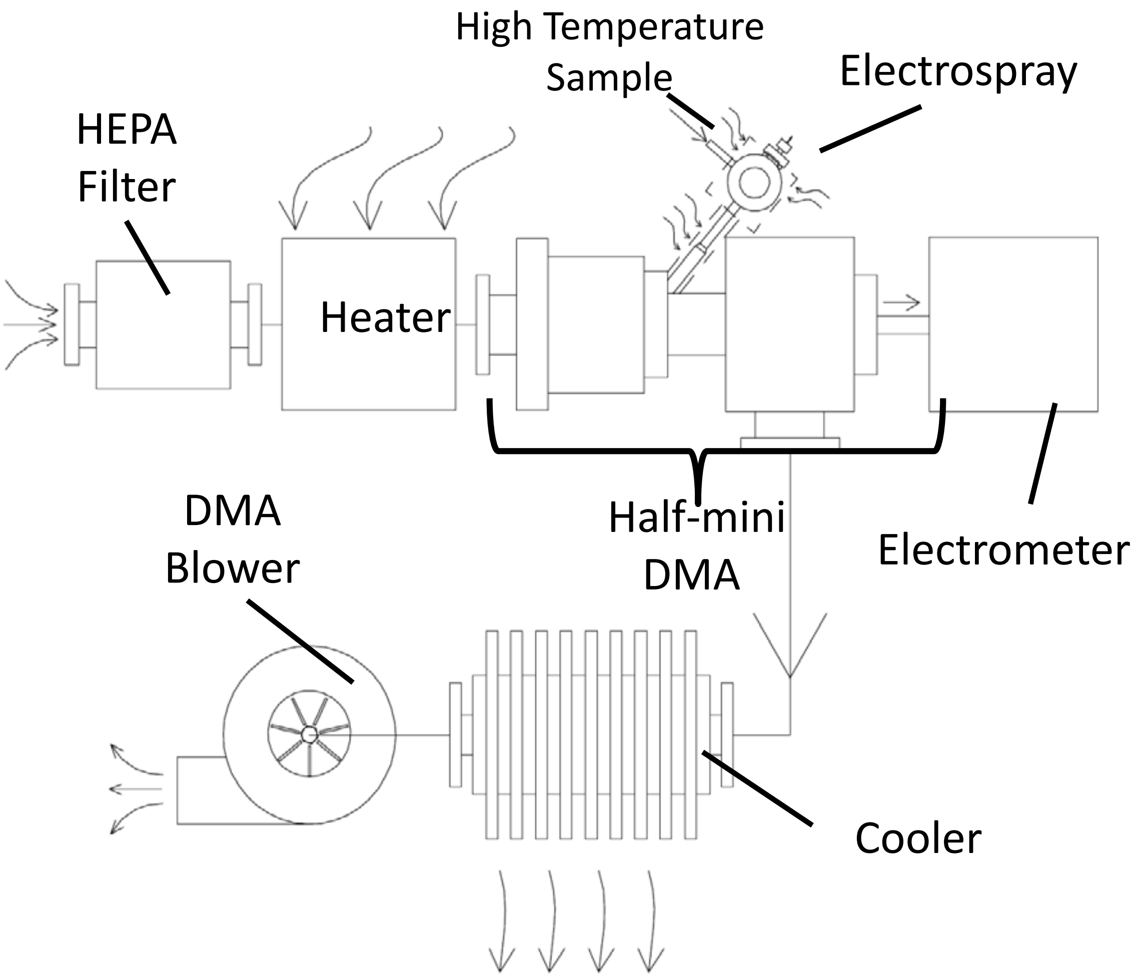
1.- Half-mini DMA



- Compact and light: 2.7 kg
- Particle size range: 1-30 nm
- High resolution: 30 for 1.4 nm particle .
- Axisymmetry at the aerosol inlet provides close to ideal resolution behaviour at aerosol/sheath gas flow rates of 10%

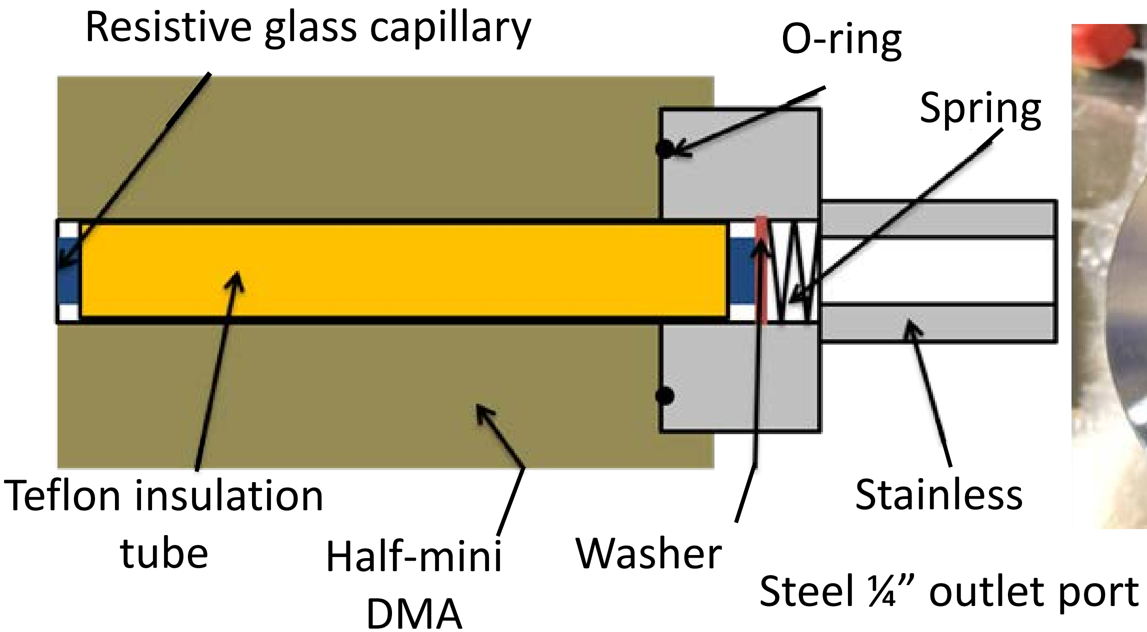
- Suitable for small nanoparticles from exhaust engines.

2.- Half-mini DMA high temperature configuration



- High temperature tolerant materials: stainless steel, Peek, Viton and resistive glass
- Gas heater: sheath gas temperatures up to 200°C.
- Sheath gas open circuit to maintain the sheath gas free of sample vapors.
- Suction in pump to facilitate ambient gas sampling
- Cooler before the DMA blower to prevent blower overheating
- A heating jacket heats the ionization source and the aerosol inlet line

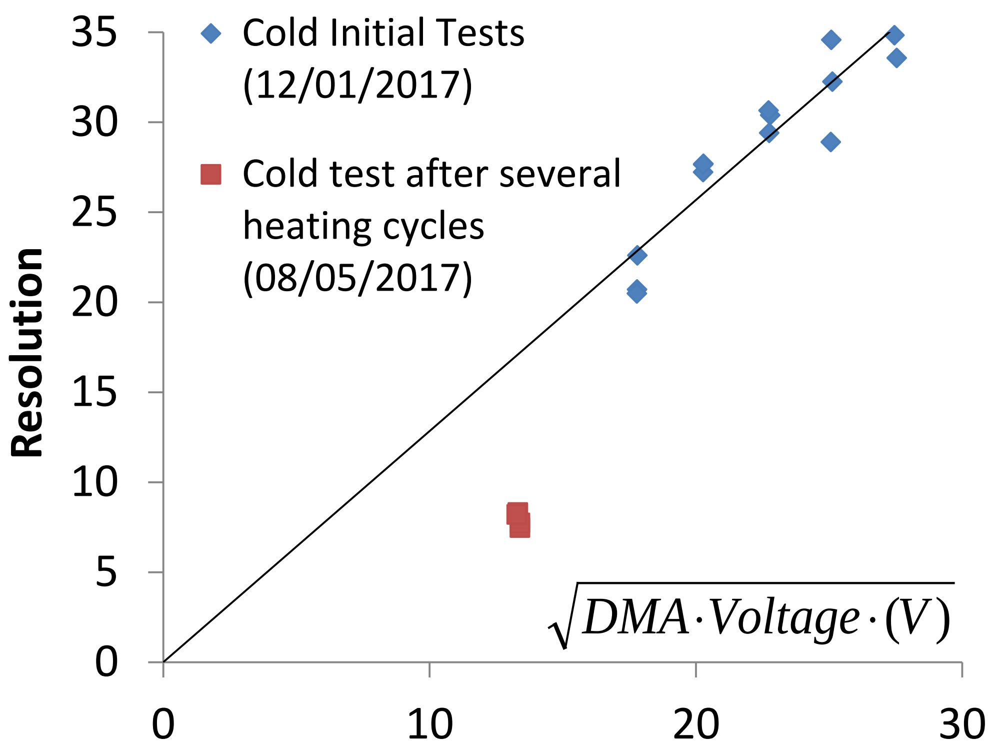
3.- Change of materials at the DMA outlet



The static dissipative polyurethane tube was substituted with a resistive glass capillary (581 MegaOhms, Photonis, USA).

The DMA insulator was made of Peek, a plastic with a maximum temperature of 250 °C, so this part is not initially modified.

4.- Loss of resolution due to thermal fatigue

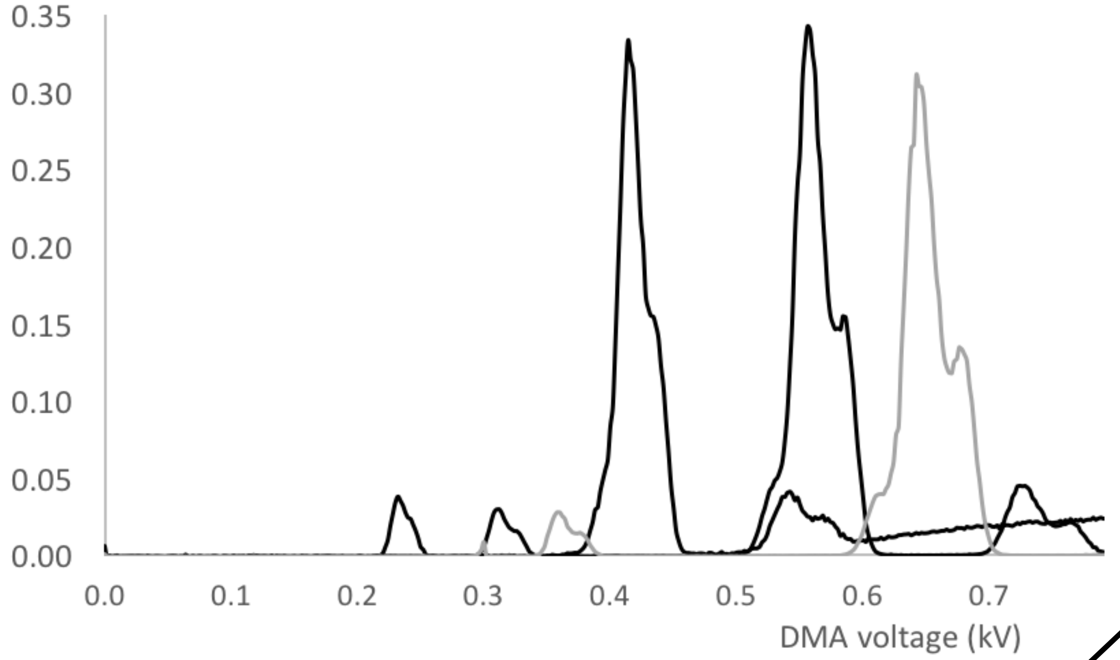


After several heating cycles there was a permanent loss of resolution.

Reason?

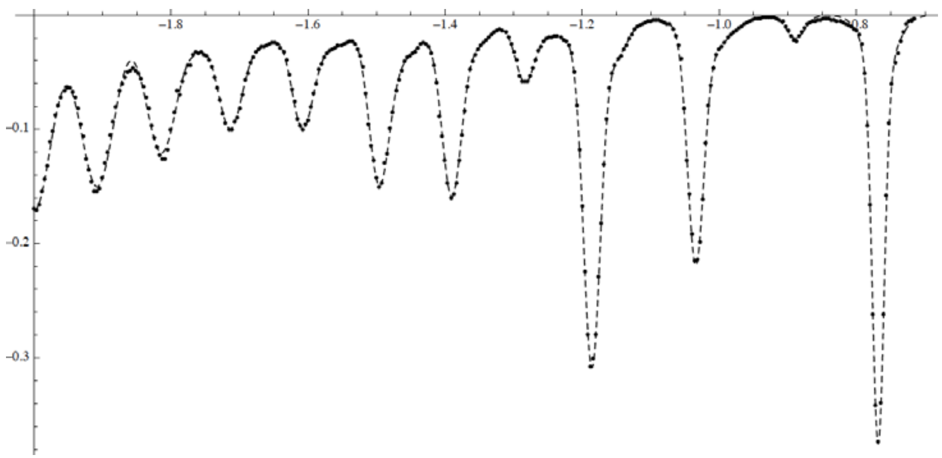
The Peek coefficient of linear thermal expansion is very large compared to the stainless steel one, causing undesirable deformations and finally a loos of centering in the DMA bullet shape electrode.

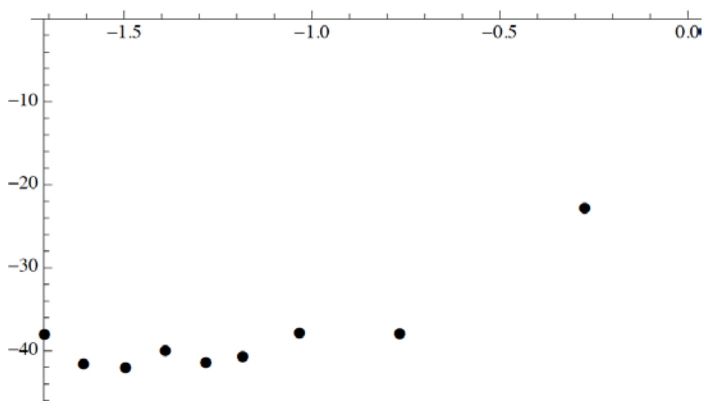
Loss of resolution from deformed insulator



Metal-PEEK-metal sandwich for precision centering of inner electrode

5.- Material change of the DMA centering insulator





First candidate:

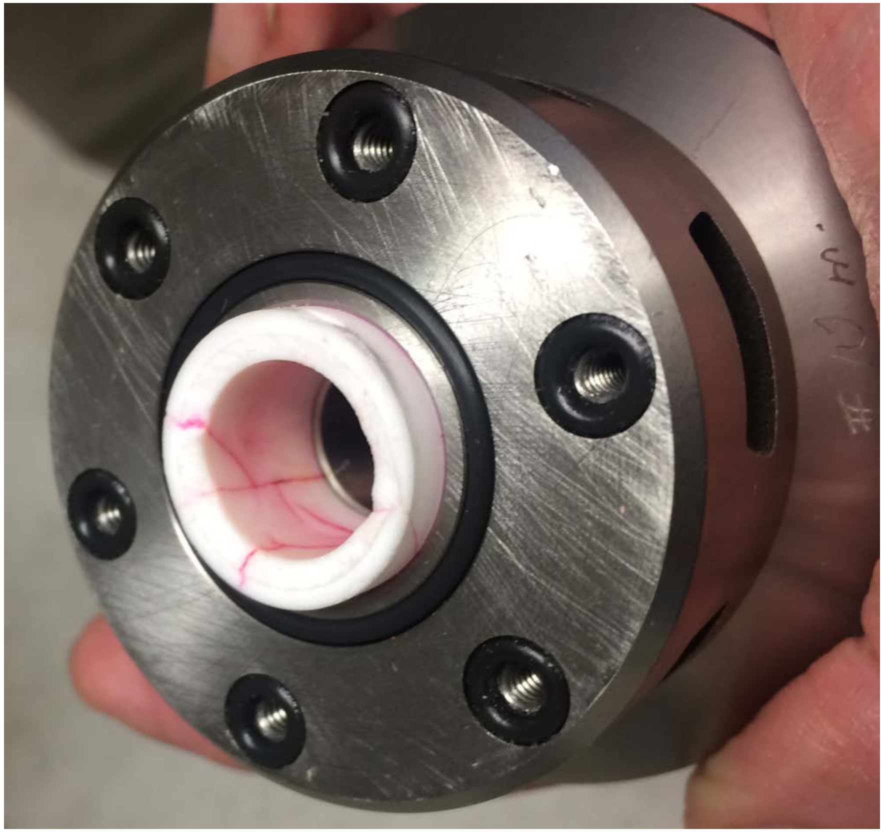
Macor: is a machinable ceramic with a coefficient of linear thermal expansion slightly lower than stainless steel.

Macor widens size range by allowing a higher voltage (6.4 kV vs 5 kV)

Macor withstands several hours under 180 C without loss of resolution

However, after heating, maximum voltage of operation is reduced to 4.4 kV. Cracks suspected, though no loss of centering

5.- Material change of the DMA centering insulator

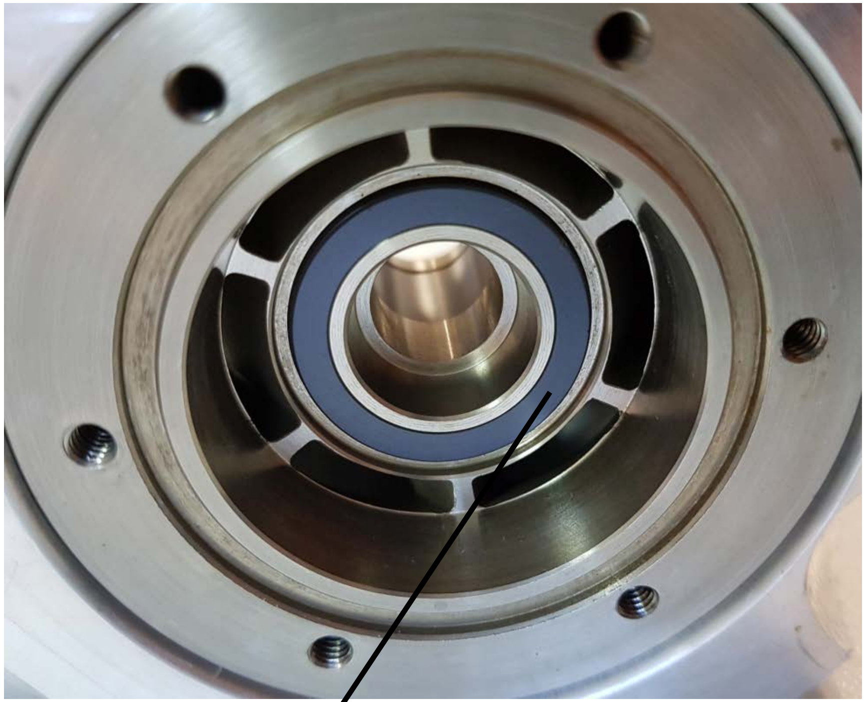


Macor: Indeed cracks become visible after coloring and washing,

More test must be carried out in order to find out if the cracking cause was a non axisymmetric application of heat.

For the moment, macor was discarded because of its fragility and associated size range reduction.

5.- Material change of the DMA centering insulator



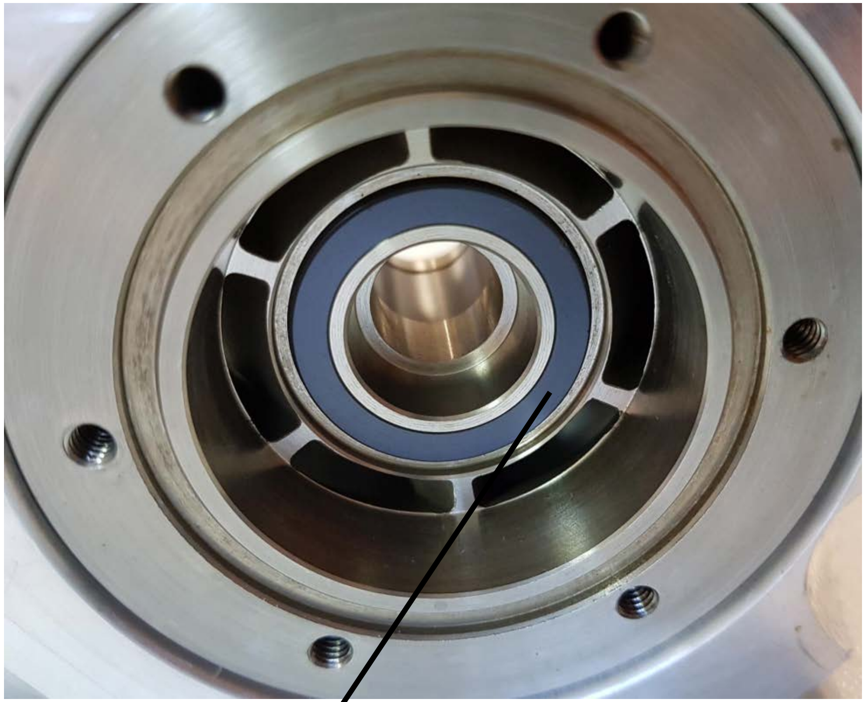
High performance plastic insulator

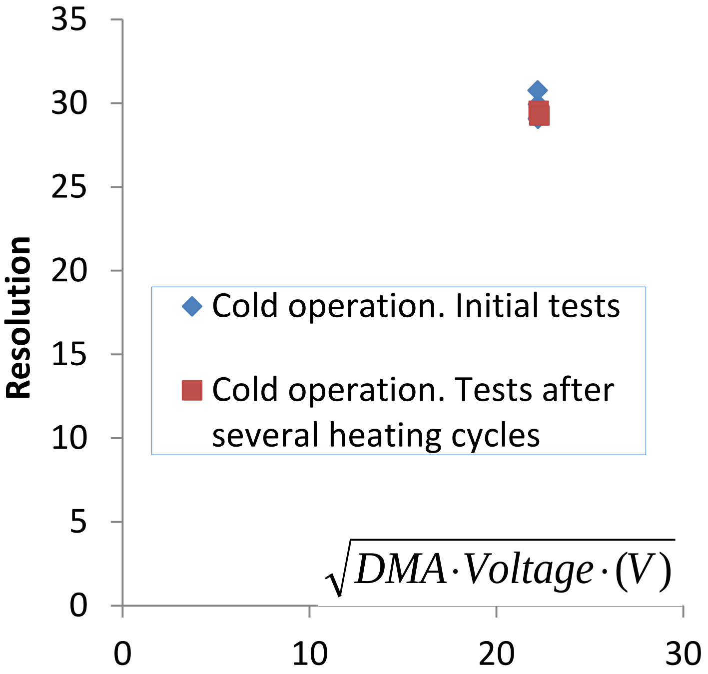
Second candidate:

high performance plastic with:

- Glass transition temperature well above 200 °C
- Coefficient of linear thermal expansion only slightly larger than in stainless steel.
- Once tested, maintains resolving power after heating: No plastic deformations!

6.- Results





High performance plastic insulator

7.- Conclusions

- The Half-mini DMA has been adapted to work continuously at temperatures of 200°C, maintaining its high resolving power. Materials improvements are required on antistatic outlet and on insulator centering inner electrode
- At the moment it is being validated in engine exhaust benches under Sureal-23 project.
- Application of the DMA results in engine exhaust emissions please visit the **poster TP-49** presented today, and titled :

" *High-temperature solid particle emission measurements in the sub-23 nm mobility size range with the advanced half-mini DMA*"

(P. Baltzopoulou, A.D. Melas, D. Deloglou, N.D. Vlachos, E. Papaioannou, J.F. de la Mora, A.G. Konstandopoulos)."

8.- Acknowledgements

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Thanks for your attention

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