EXPERIMENTAL INVESTIGATIONS ON THE FREQUENCY DEPENDENCE OF THE CLAUSIUS-MOSSOTTI FACTOR FOR NANO/ MICROPARTICLES CONTAINED IN THE EXHAUSTED FLUE GASES OF INCINERATORS

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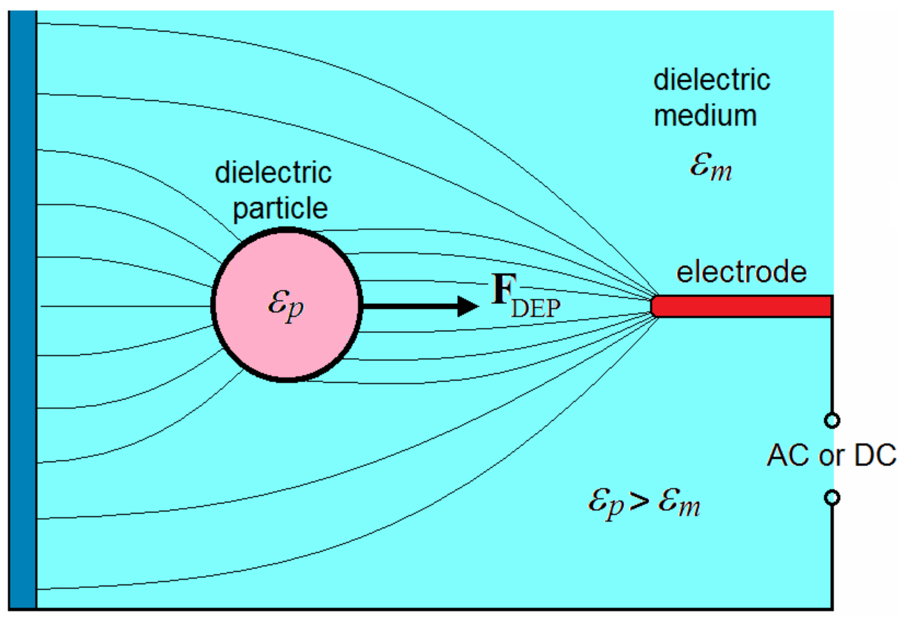
Abstract

This work presents investigations regarding the frequency dependence of the Clausius-Mossotti (CM) factor performed on nano/microparticles powders resulted from combustion processes waste, taken from the flue gas filters of one hazardous wastes incineration plant. The frequency dependence of the complex dielectric permittivity of the mixture, over the range 25 Hz – 2 MHz, of the nano/microparticles samples was measured. Based on these measurements and using the Maxwell-Wagner model, we determined the frequency dependence of the real part of the Clausius-Mossotti factor, for the powders samples dispersed in different fluid media (air and the kerosene, respectively). These preliminary obtained results show the possibility to filter the exhausted combustion gases using dielectrophoresis (DEP), phenomenon that induces spatial movement, depending on the dielectric properties of the particles and the surrounding medium. Due to the specific behavior of the CM factor, DEP can be used for retaining through manipulation and controlled spatial separation of submicron particles suspended in exhausted combustion gases, leading to their purification.

Work material

Sample is a nano/microparticles powder resulted from combustion processes waste, taken from the flue gas filters of the Pro Air Clean Timisoara incinerator

Mathematical model



Electrically neutral particle in the presence of a spatially non-uniform electric-field.
The dipole moment induced within the particle results in a translational force and the dielectric spherical particle undergoes a DEP motion.

Dielectrophoretic force:

$$\mathbf{F}_{DEP} = \mathrm{Re}\{(\mathbf{m}(\omega)\cdot\nabla)\mathbf{E}\}$$

Clausius-Mossotti factor:

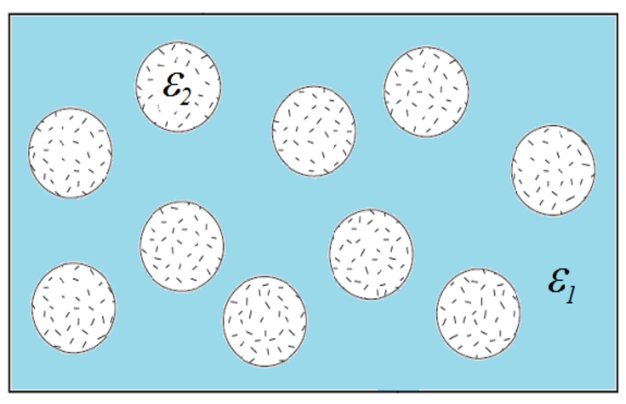
$$\tilde{K}(\omega) = \frac{\tilde{\varepsilon}_p - \tilde{\varepsilon}_m}{\tilde{\varepsilon}_p + 2\tilde{\varepsilon}_m}$$

The complex dielectric permittivity:

$$\tilde{\varepsilon} = \varepsilon' - i\varepsilon''$$

$$\varepsilon' = \frac{C_p}{C_0};\ \varepsilon'' = \frac{Q_0 C_0 - Q_p C_p}{Q_p C_0}$$

Model Maxwell-Wagnerin consider that the sample is a mixture of a host matrix (a medium with dielectric permittivity), containing inclusions of ash with permittivity.



The geometry of mixture: isotropic spherical dielectric inclusions

The complex dielectric permittivity of the mixture:

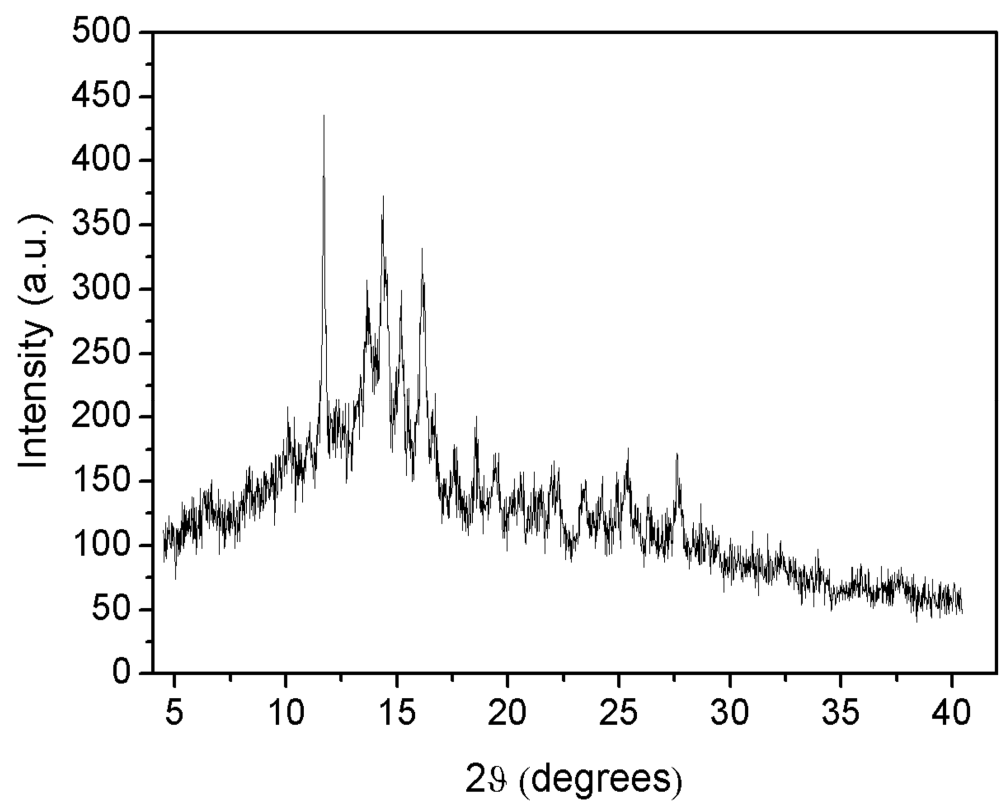
$$\tilde{\varepsilon}_{eff} = \tilde{\varepsilon}_1 + 3\tilde{\varepsilon}_1 \frac{\tilde{\varepsilon}_2 - \tilde{\varepsilon}_1}{\tilde{\varepsilon}_2 + 2\tilde{\varepsilon}_1}\cdot\Phi_2 \qquad \tilde{K}(\omega) = \frac{\tilde{\varepsilon}_{eff} - \tilde{\varepsilon}_1}{3\tilde{\varepsilon}_1}\cdot\frac{1}{\Phi_2}$$

The real and imaginary components of the Clausius-Mossotti factor:

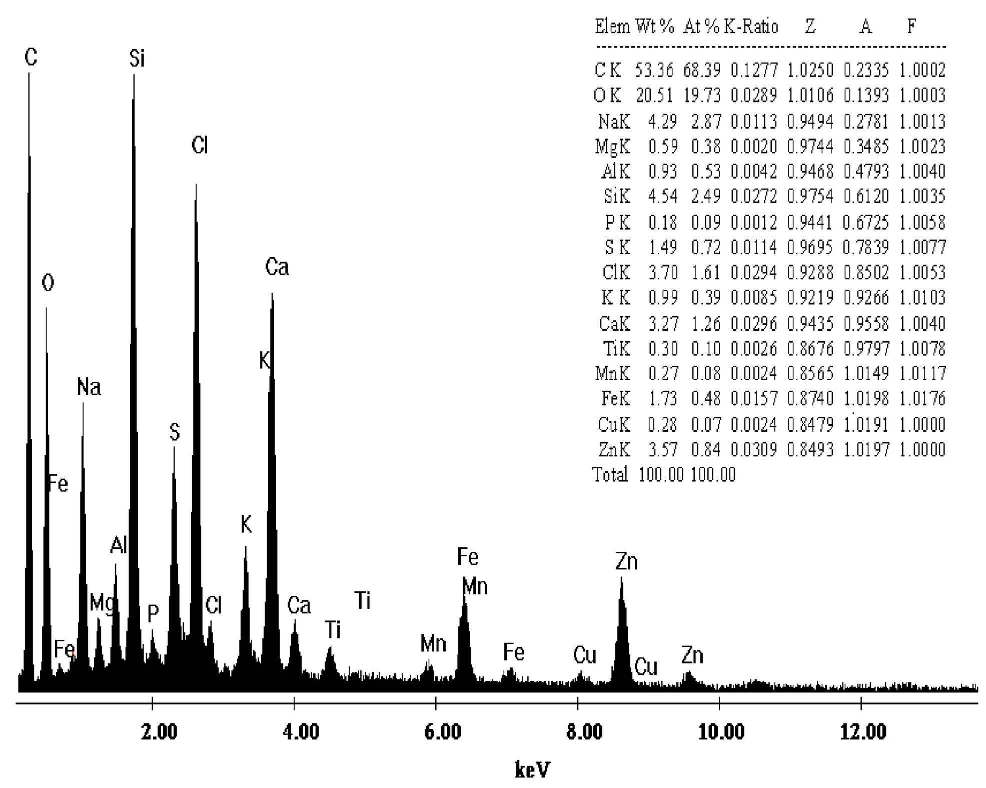
$$\mathrm{Re}[\tilde{K}(\omega)] = \frac{\varepsilon'_{eff} - 1}{3}\cdot\frac{1}{\Phi_2} \qquad \mathrm{Im}[\tilde{K}(\omega)] = \frac{\varepsilon''_{eff}}{3}\cdot\frac{1}{\Phi_2}$$

Experimental results

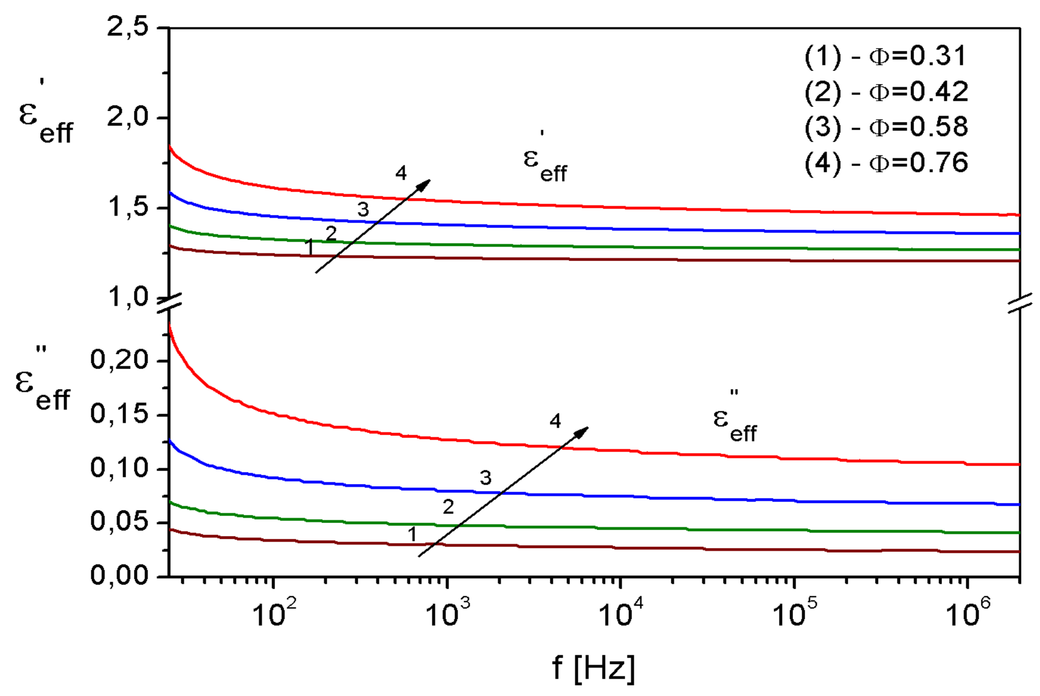
Structural and experimental characterization of the sample



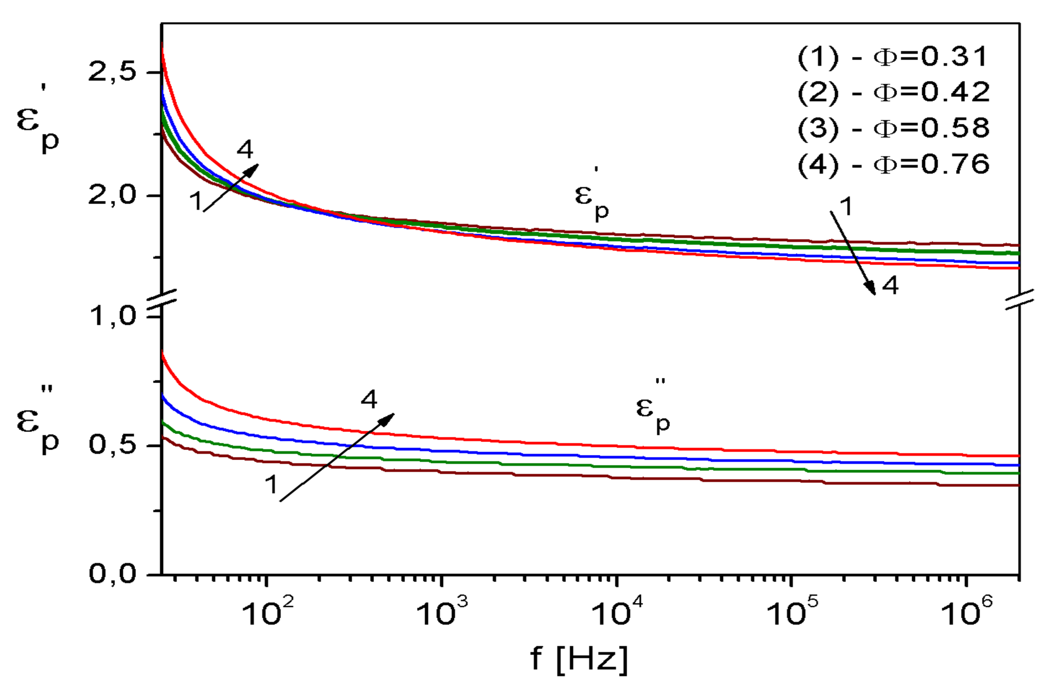
X-ray diffraction spectrum, for powder ash investigated sample



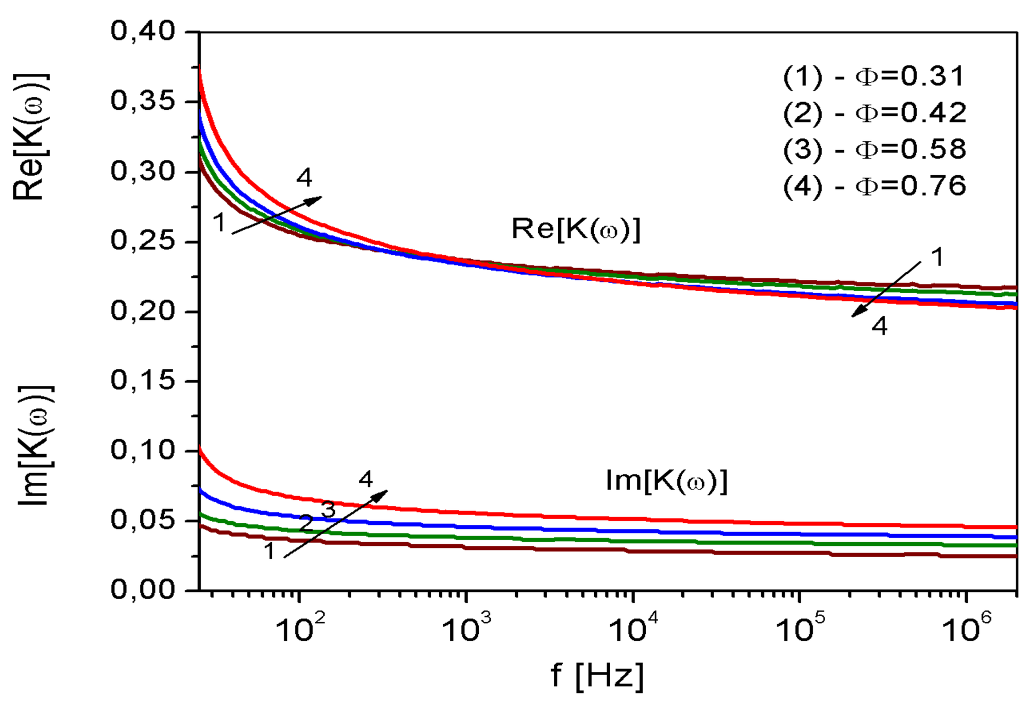
EDAX quantification of sample. The EDAX analysis has indicated a high content of carbon in the investigated sample.



The frequency dependence of the measured real , and imaginary , components of the effective complex dielectric permittivity, for investigated sample and for different volume fraction of ash particles in the mixture



The frequency dependence of the calculated real, and imaginary components of the complex dielectric permittivity of the ash particles for different volume fraction.



The frequency dependencies of the real and imaginry part of the Clausius-Mossotti factor, for ash-air mixture sample, with different volume fractions of ash particles in the mixture.

Conclusions

- Based on dielectric measurements of the real, and imaginary components of the complex dielectric permittivity in the range 25Hz - 2MHz, for nano/ micropartices powders, resulted from combustion processes waste, taken from the flue gas filters of one hazardous wastes incineration plant, we determined the frequency dependence of the real part of the Clausius-Mossotti factor, in air and kerosene.
- Using the Maxwell-Wagner model, for a mixture with two phases, we computed the real and imaginary components of the complex dielectric permittivity of the ash particles.
- These preliminary obtained results show the possibility to filter the combustion gases, using dielectrophoresis.

References

[1] Herbert A. Pohl H.A., *Dielectrophoresis*, Cambridge Univ. Press, UK, (1978).

[2] N.G. Green, A. Ramos, H. Morgan, Journal of Electrostatics **56**, 235-254 (2002).

[3] Zhang C. et al, Anal. Bioanal. Chem. **396**, 401-420 (2010)

[4] Voldman J., Annu. Rev. Biomed. Eng. **8**, 425-454 (2006)

[5] Pething R., Biomicrofluidics **4**, 022811 –1-35 (2010)

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