Thermoplastic / Carbon NanoTubes nanocomposites for promoting conductivity in polymeric based structures

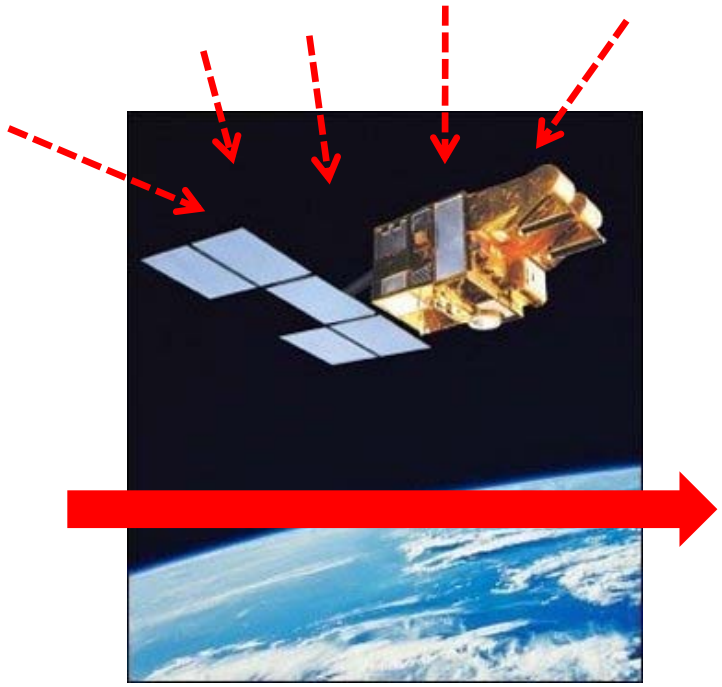
D. Carponcin, E. Dantras, L. Cadièrgues, G. Aridon, F. Levallois, C. Lacabanne

7th ESA Round table on MNT for Space Applications. 13-17 sept 2010.

Outline

- Materials : conductive nanocomposites
- Physico-chemical characterization
- Elaboration by solvent way and extrusion
- Control of the dispersion using electrical conductivity

Continuous bombardment of charged particles



Charges accumulation

Differences of potential between many parts of the satellite

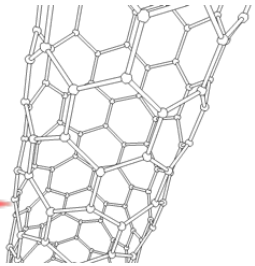
Structural material evacuating electrical charges

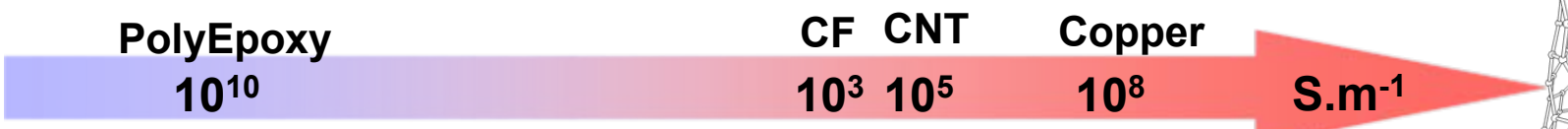
Polymer matrix : POLYAMIDE 11 $[-CO-(CH_2)_{10}-NH-]_n$

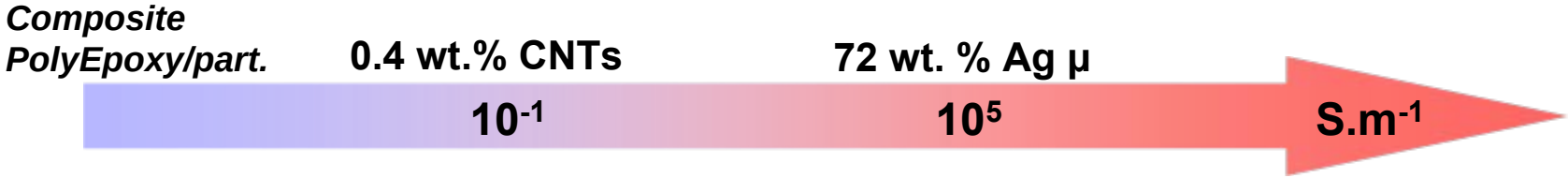
Semi-crystalline thermoplastic

- **Crystalline phase: T_m = 188°C**
- **Amorphous phase: T_g = 48°C**

Conductive nanoparticles: CNTs





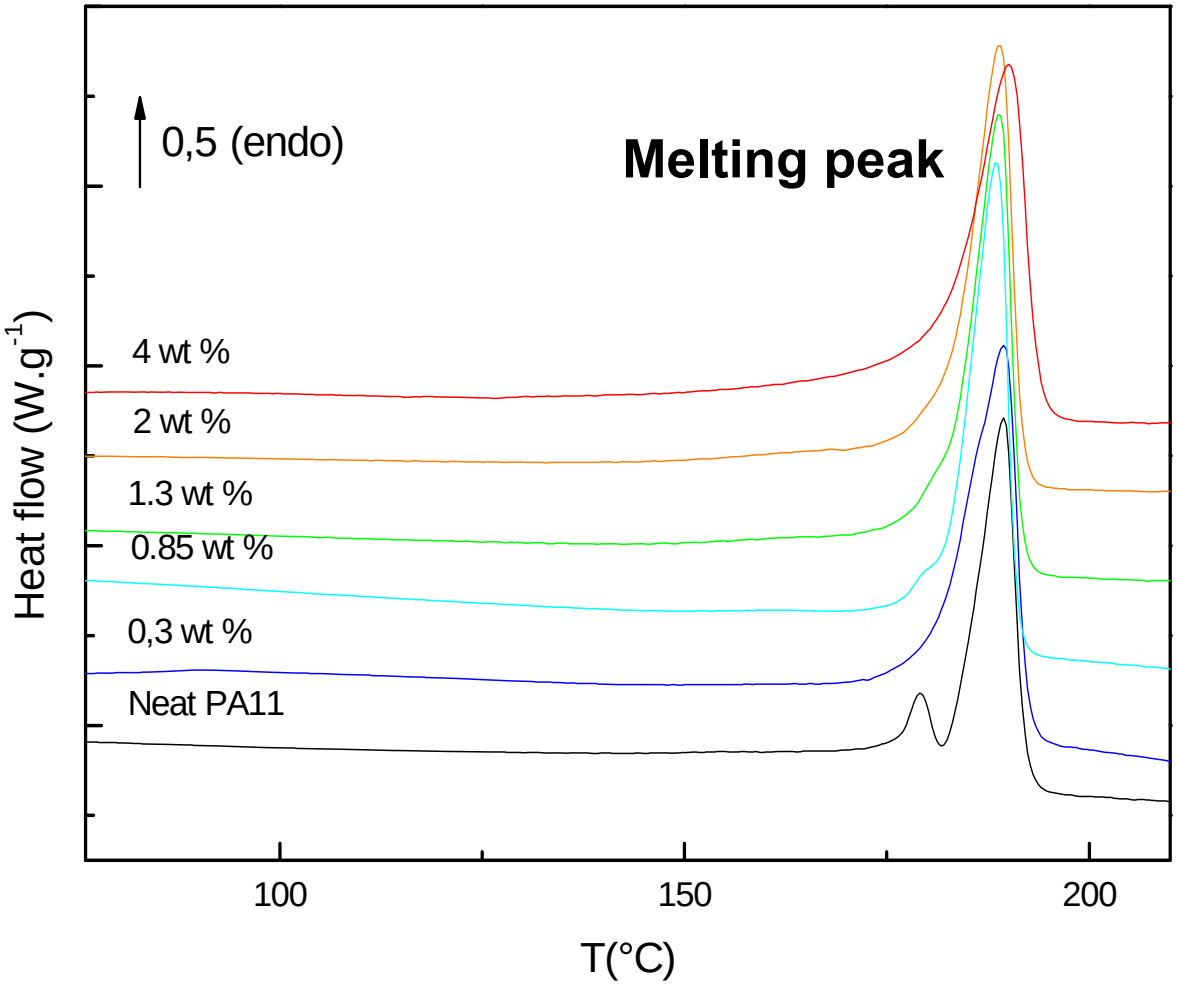


$$\text{Aspect ratio} = \frac{length}{diameter}$$

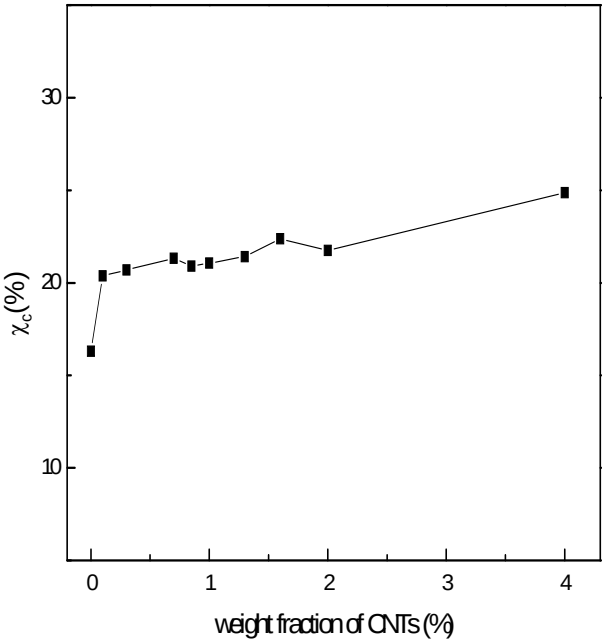
High aspect ratio
=> percolation at low CNTs content
=> Ductility of the polymer matrix

PHYSICO-CHEMICAL CHARACTERIZATION

Physical structure characterization

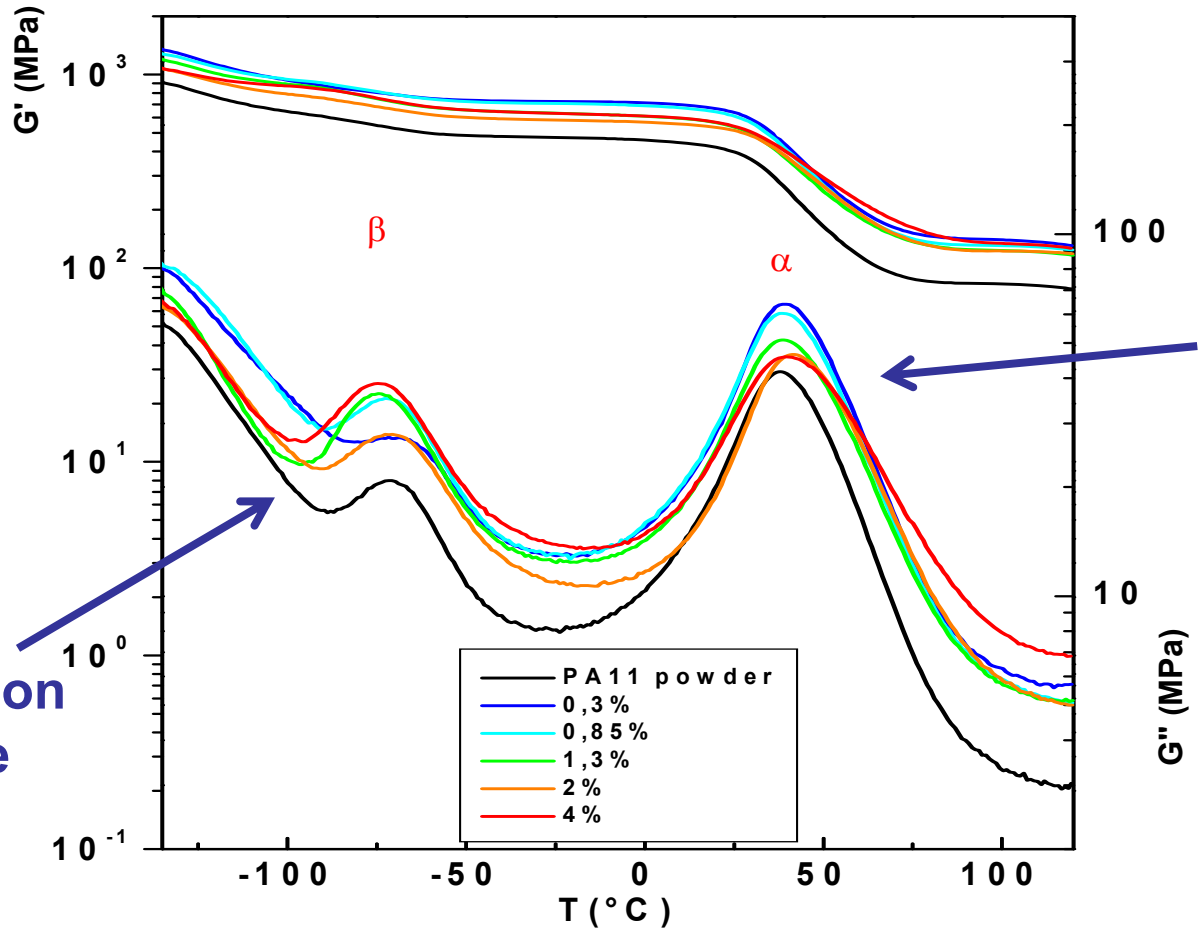


Ratio of crystallites



Weak influence of CNTs on crystallinity ratio

Mechanical characterization



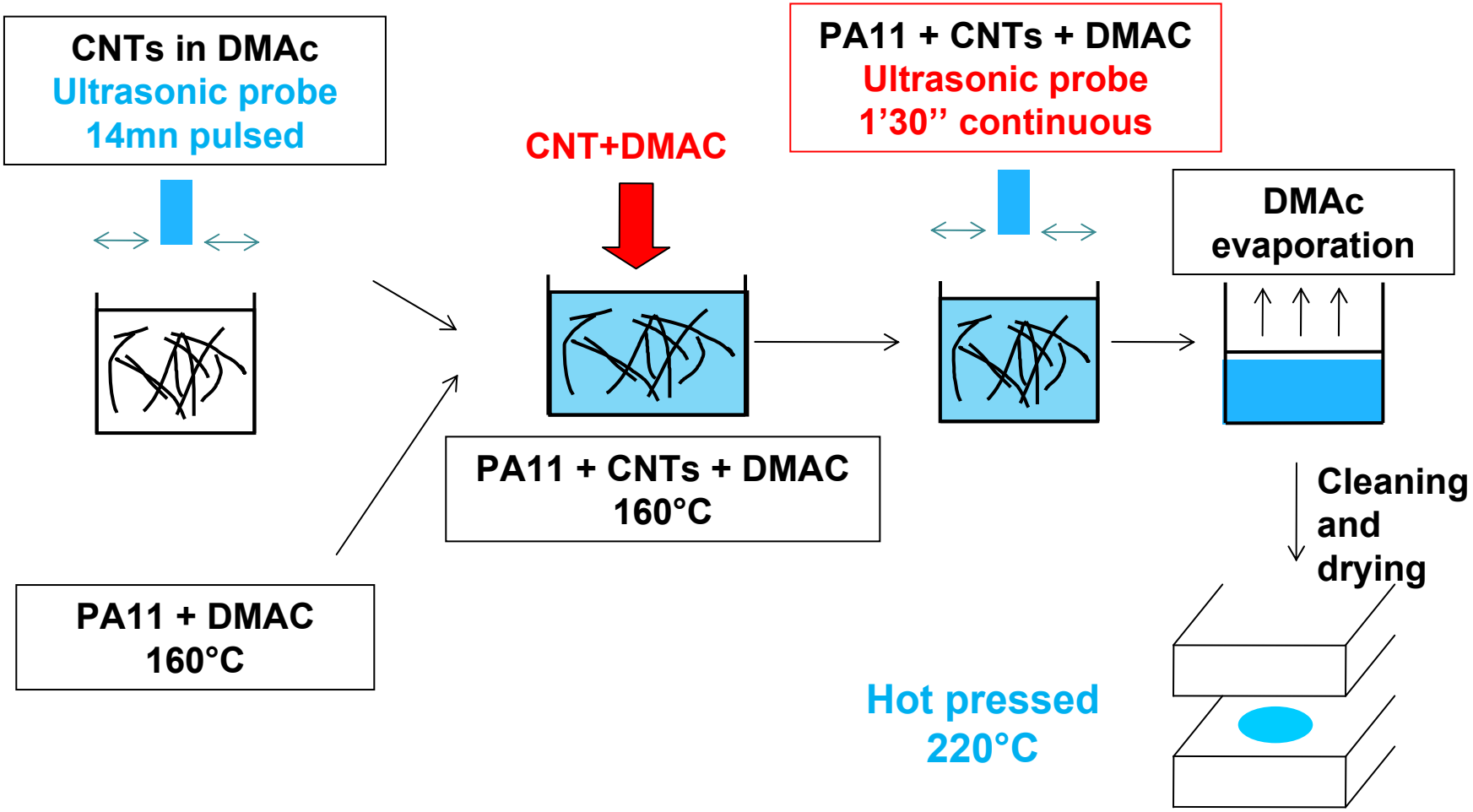
α : primary relaxation

β : relaxation of amide groups

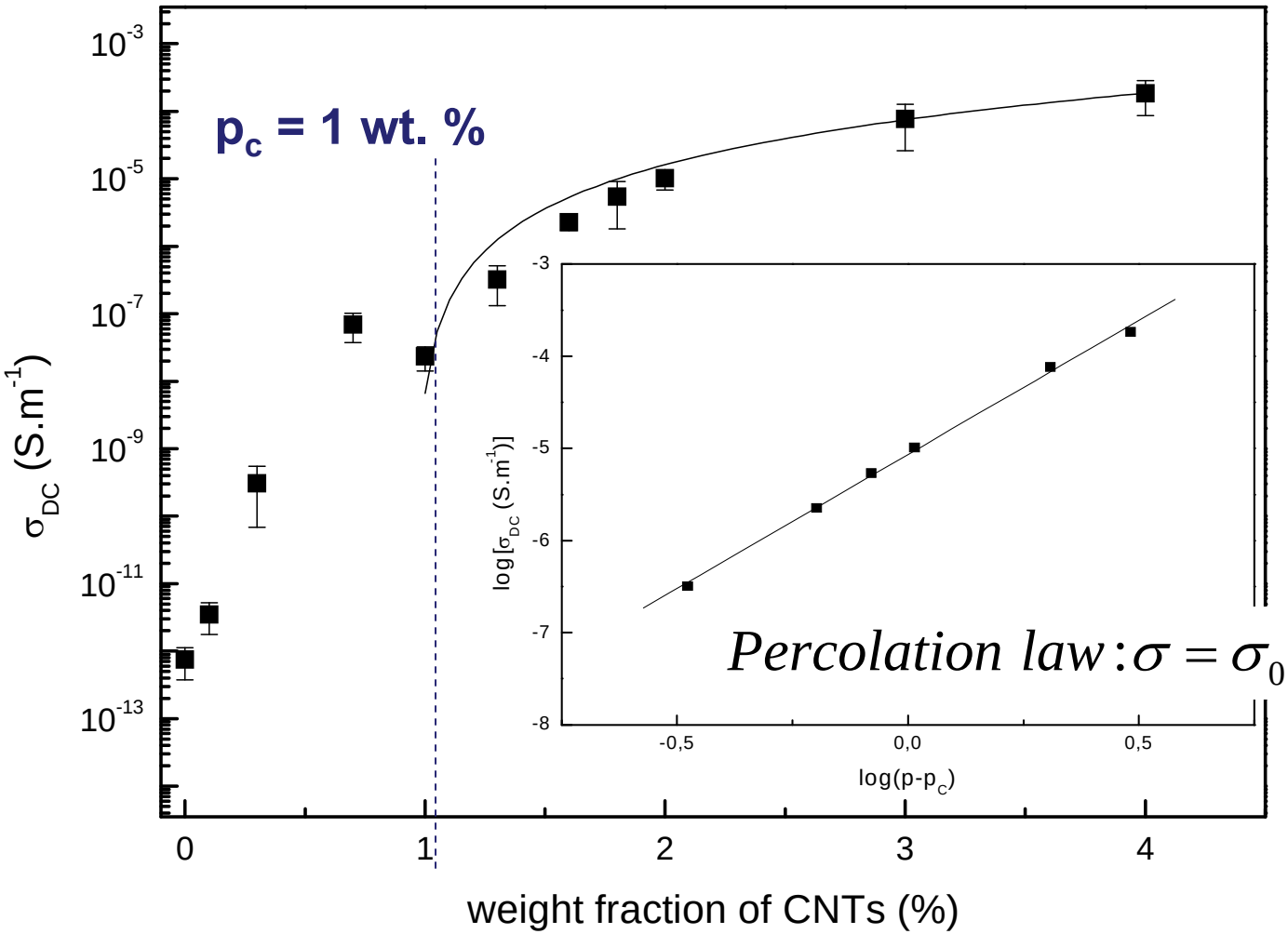
Persistence of viscoelasticity upon CNTs introduction

NANOCOMPOSITES ELABORATION

Nanocomposites elaboration by solvent way



Nanocomposites elaboration by solvent way

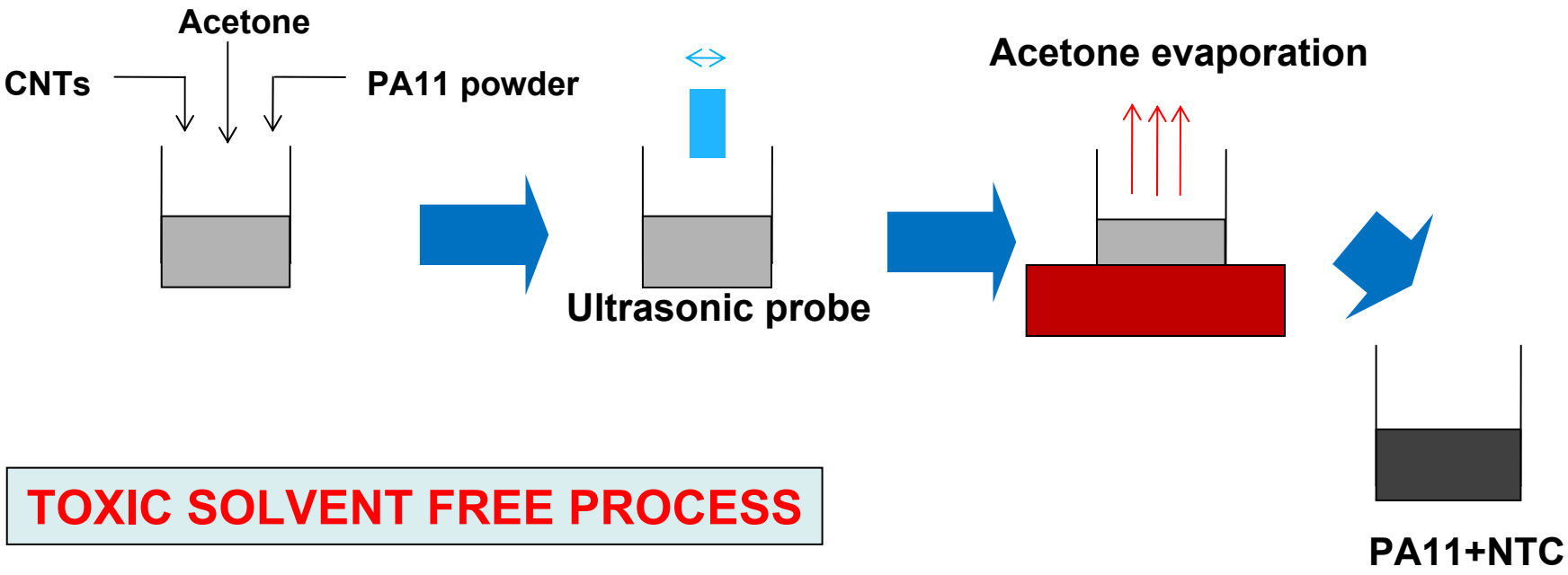


$$Percolation\ law: \sigma = \sigma_0 (p - p_c)^t$$

t = 2.02

Insulator – conductive transition for 1 wt % nanocomposites

Extrusion : an industrial process



TOXIC SOLVENT FREE PROCESS

Twin-screw extruder
- screws rotation speed
- screws rotation direction
- mixing time
- mixing temperature

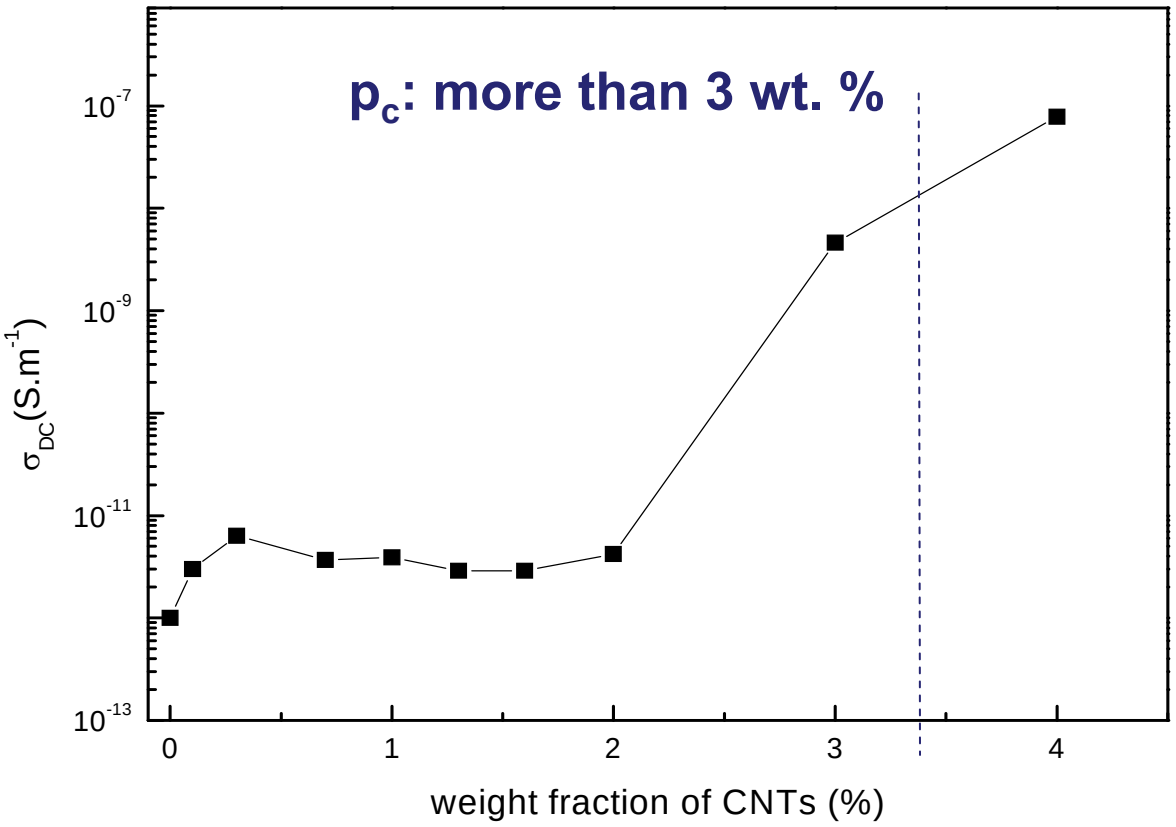
CONTROL OF THE DISPERSION USING ELECTRICAL CONDUCTIVITY

cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES

EADS astrium

Extrusion initial parameters

Composites 4 wt. %, 80 rpm, counter rotating, 30 min, 220°C

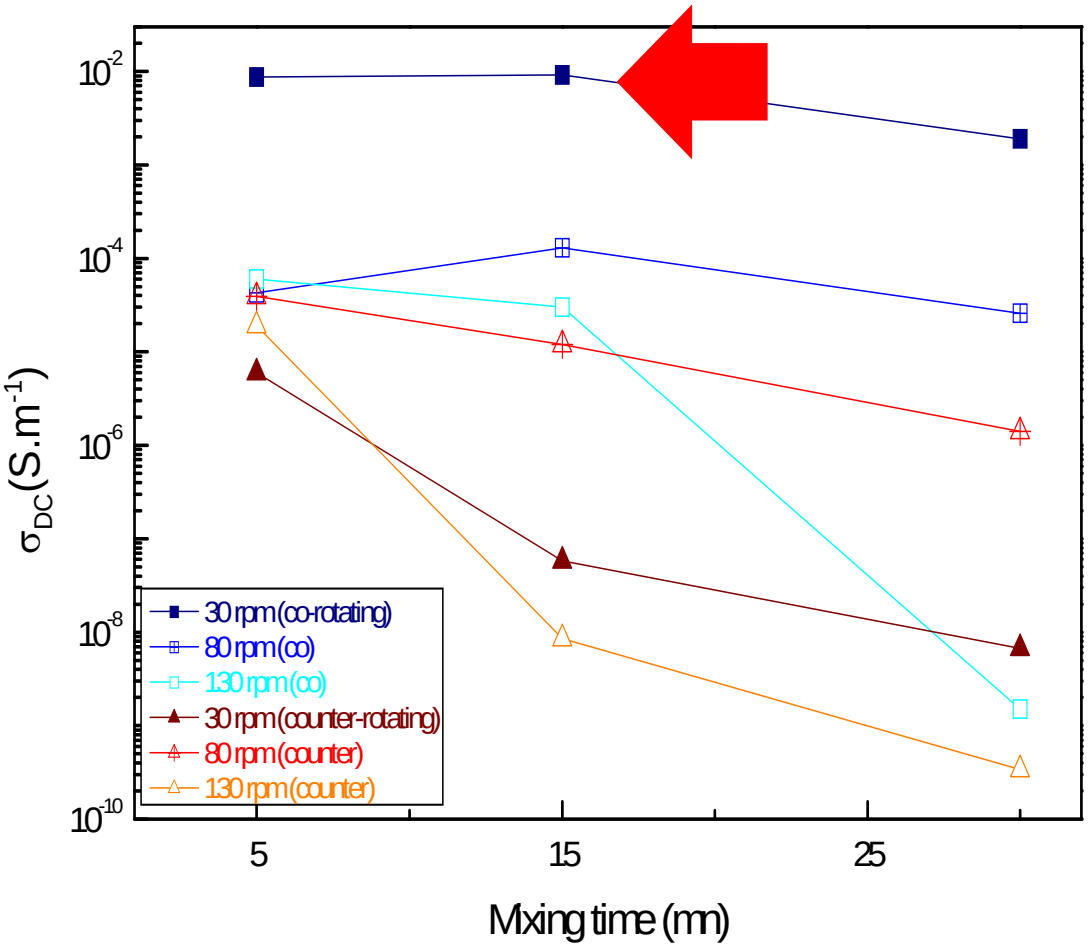


Balberg : $f.p_c = cte$

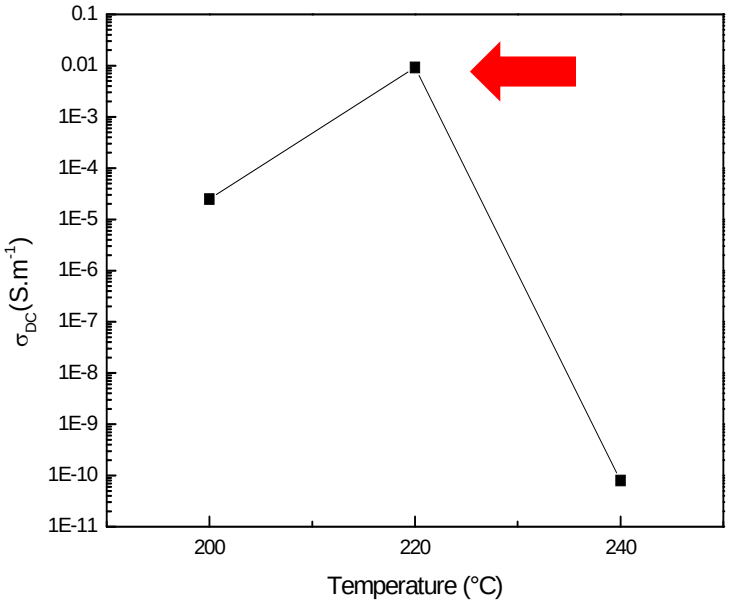
↓

High percolation threshold value: indicative of aspect ratio ↘

Influence of extrusion conditions

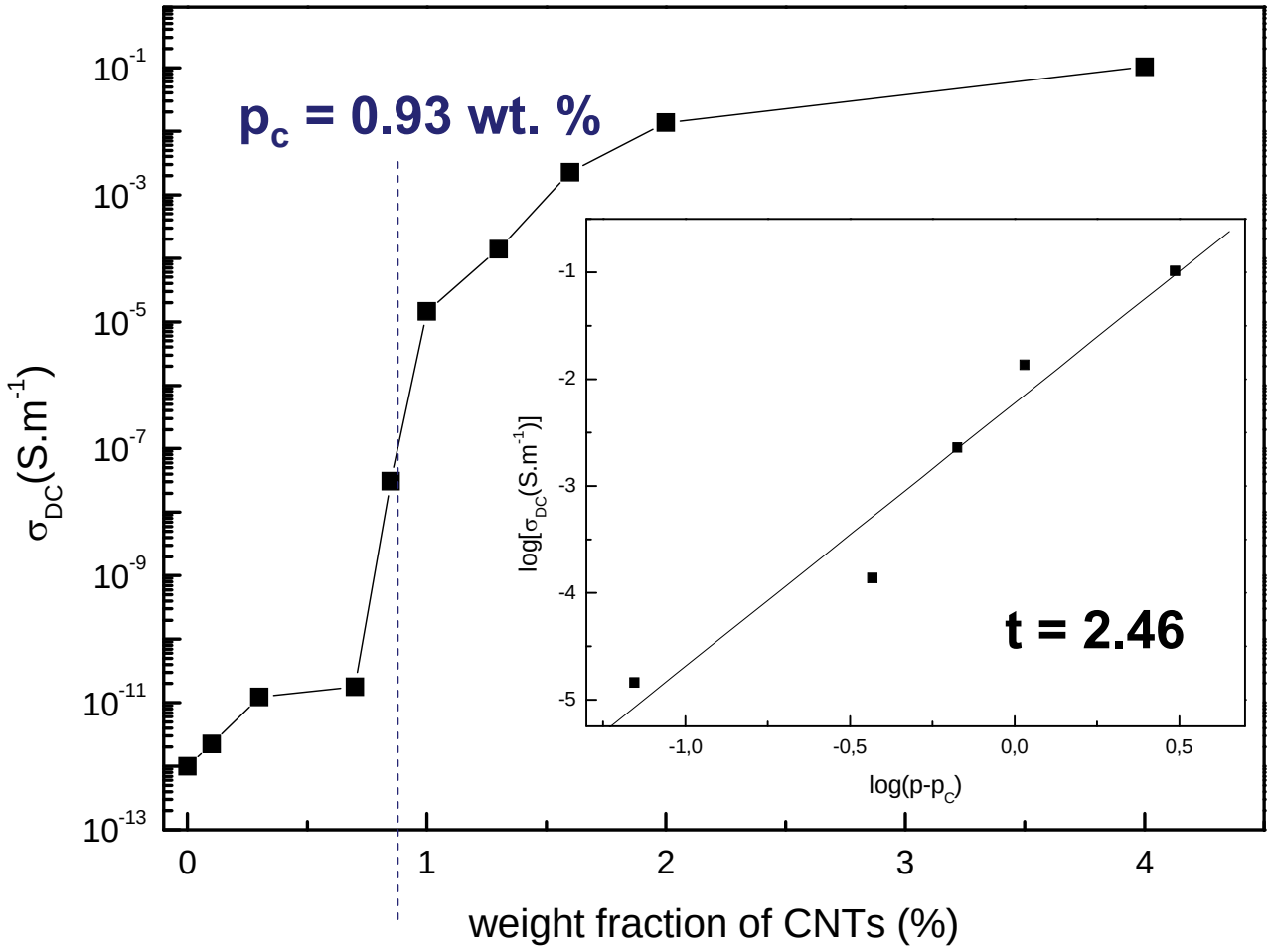


Composites at 4 wt. %



Selected processing parameters:
30 rpm, co-rotating, 15 min, 220°C

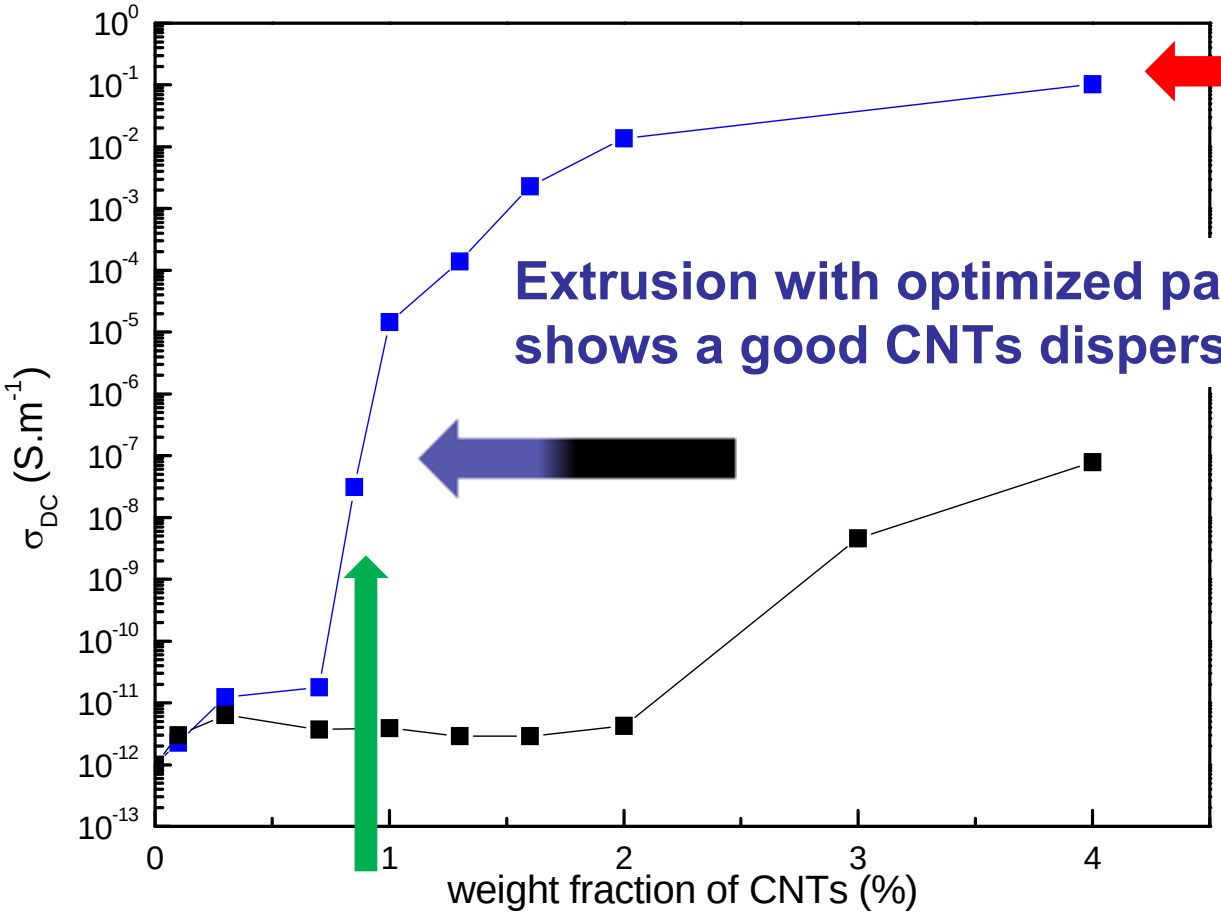
Extrusion with optimized parameters



Initial parameters
p_c = 3 wt. %

Optimized parameters
p_c = 0.93 wt. %

Percolation threshold: 0.93 wt % of CNTs



Electrical conductivity allows charge evacuation

Extrusion with optimized parameters shows a good CNTs dispersion

Conservation of mechanical properties

P_c value is one of the lowest observed in the litterature for a semi-crystalline thermoplastic polymer

APPROVE THE NANOCOMPOSITE AS A SPATIAL MATERIAL

- Evolution of the electrical conductivity under radiations
- Outgassing tests
- Thin films (100µm) or bulk

Thermoplastic / Carbon NanoTubes nanocomposites for promoting conductivity in polymeric based structures

D. Carponcin, E. Dantras, L. Cadièrgues, G. Aridon, F. Levallois, C. Lacabanne

7th ESA Round table on MNT for Space Applications. 13-17 sept 2010.