

Residual plastics as reducing agents and co-fuel in steel-making

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Production of plastics (Short life devices)

World 300 Mt/y

Europe 60 Mt/y

Residual

World ??

Europe 25,8 Mt/y

France 3,3 Mt/y

In Europe, 38 % buried in landfields, 36 % incinerated and 26 % recycled. In continuous progress.

The massive use of plastics will lead to the fact that there will be more residual plastics than fishes in the oceans in 2050!



Reuse of organic polymers

The problem is that polymers are rarely used as pure materials.

Only a very small volume is out of almost pure resins (bottles).

Rubbers contain...

Carbon blacks, precipitated silica, sulfur, plastifiers, vulcanisation additives (accelerators as Zn-thiocarbamates), special fillers and anti-ageing substances (zinc oxide associated with zinc organic salts).

In some compounds as tyres, surface treated (Cu-Zn) threads of steel, textiles.

Anti-sticking agents (hydrophobated clays and talcs).

Plastics contain...

Fillers (carbonates, talc, chlorites, silica, kaolinites...).

Anti-ageing formula e.g. phenols and titanium dioxide.

Fire retardant substances.

Adhesion primers as maleized polymers.

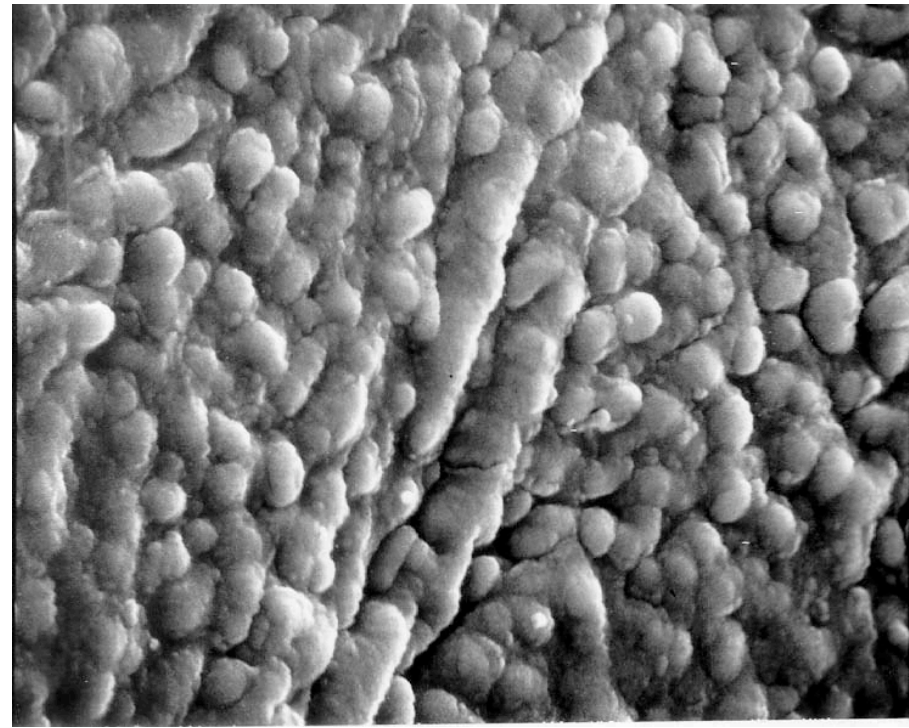
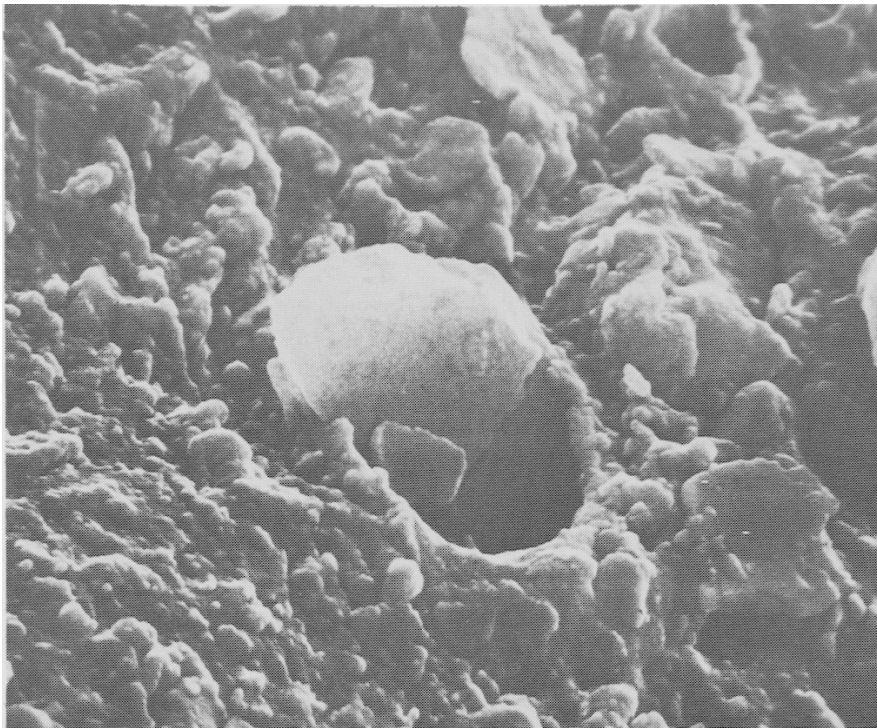
Coloured pigments as lead, cadmium and chromium compounds, residual catalysts (e.g. SbCl_5)

Kaolin in Rubber.

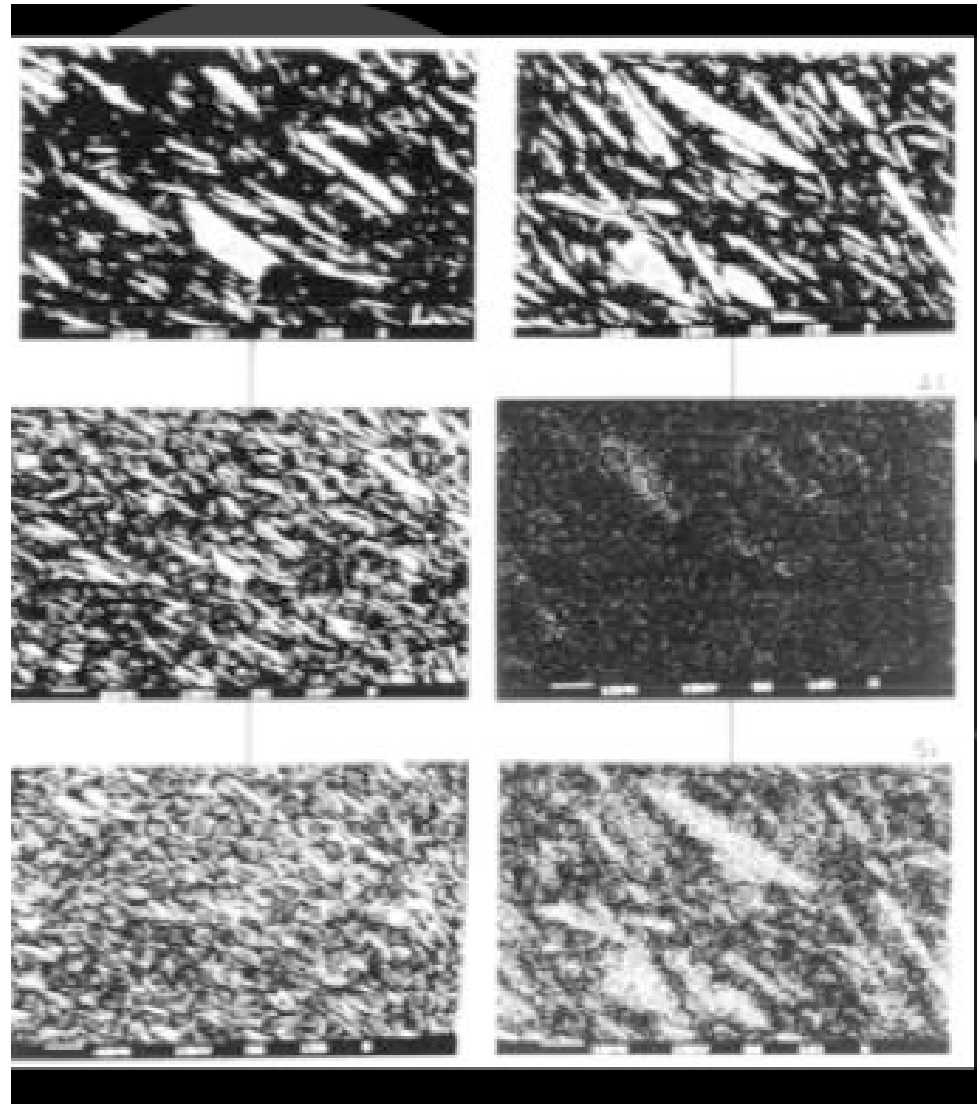
Broken face of a tensile proof of rubber (shoe sole quality). SEM secondary electrons imaging.

Left : mica-like particle Illite ($5\mu\text{m}$).

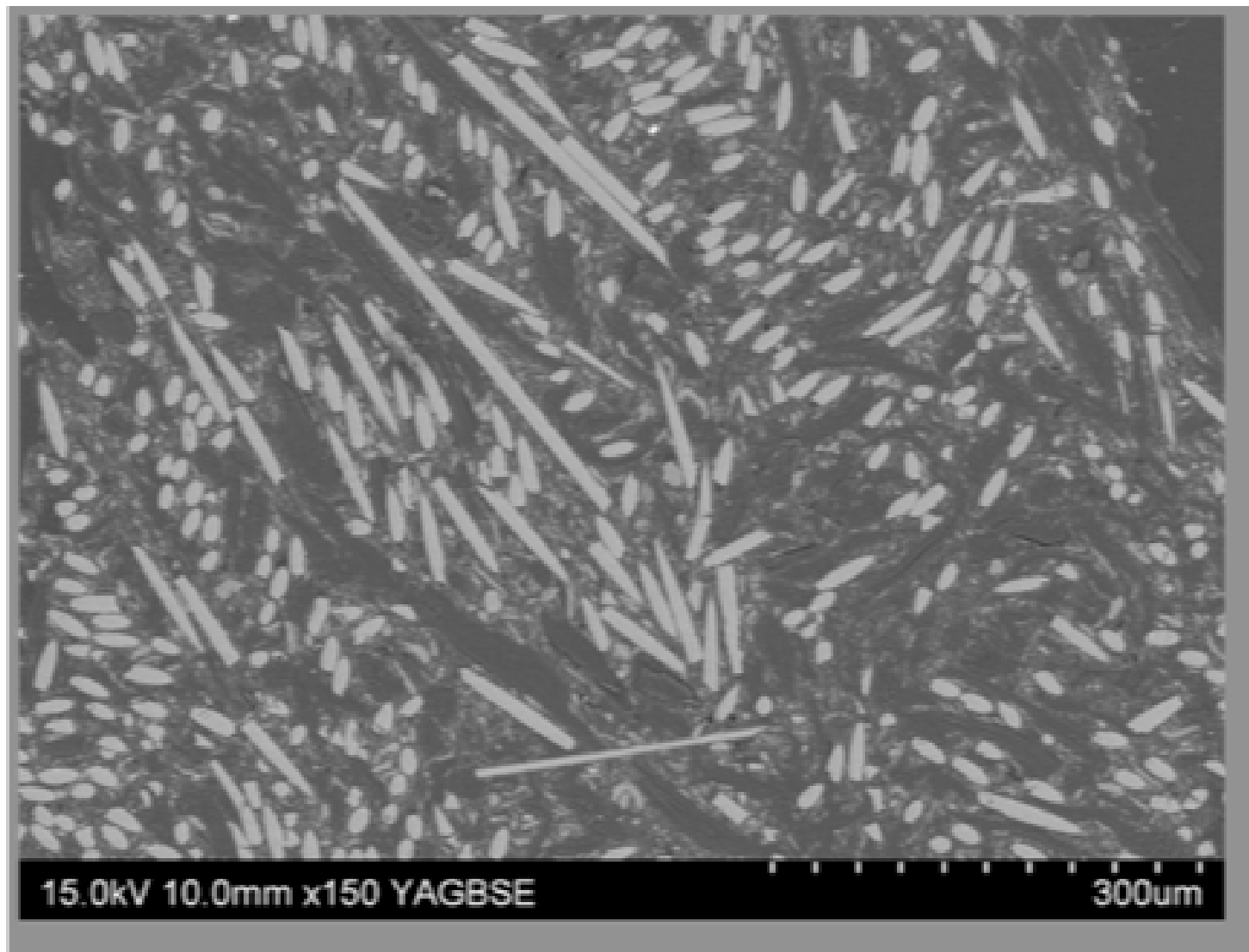
Right, grafted particles of surface treated kaolinite embedded in the polymer ($2\mu\text{m}$).



Polished section of talc reinforced polypropylene.
Sem : left back scattered electrons imaging, right X-ray
emission imaging of Al and Si.



Fibre reinforced plastic : polished section, back scattered imaging.

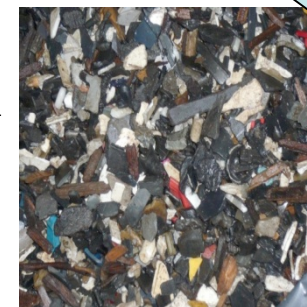
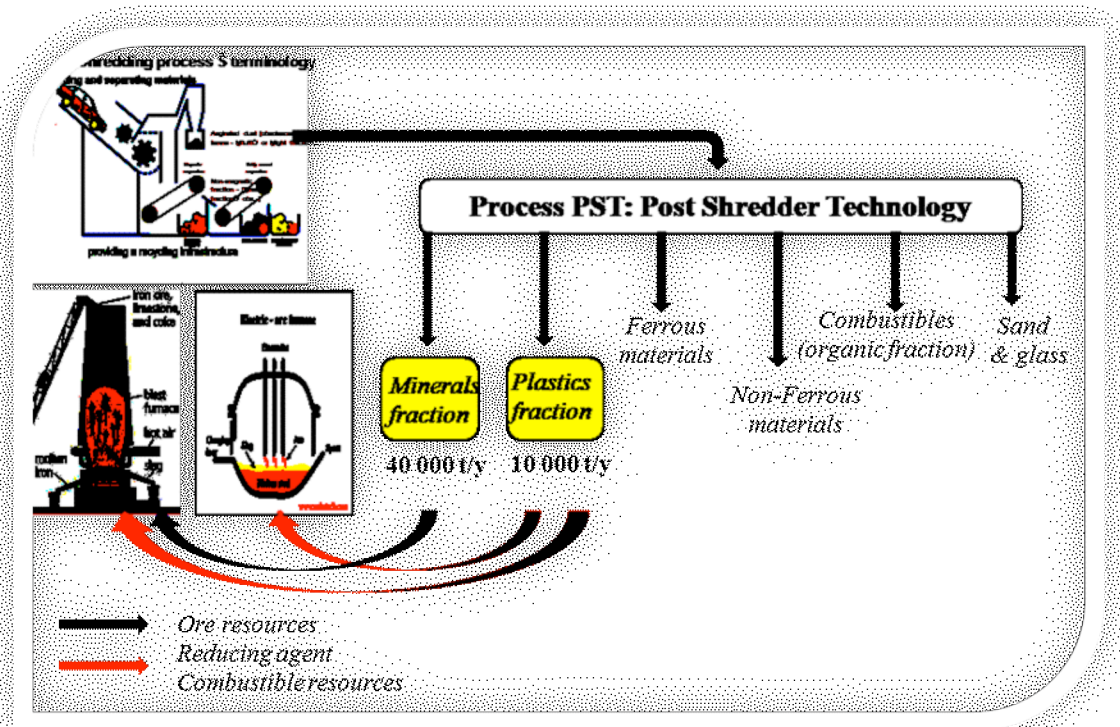


Residual Plastics as a New Fuel?

Lower heating value (LHV)

	LHV MJ/kg
Natural Gas	52
Polypropylene (PP)	44
Polyethylene (PE)	43
Petrol fuel	42
Polyamide	37 + NO_x
Coal	29 + SO_x
PMMA	25
PVC	20 + R-Cl
Wood	16 + ashes
Paper	14 + ashes
Plastic composites (average)	10 + ashes

Materials



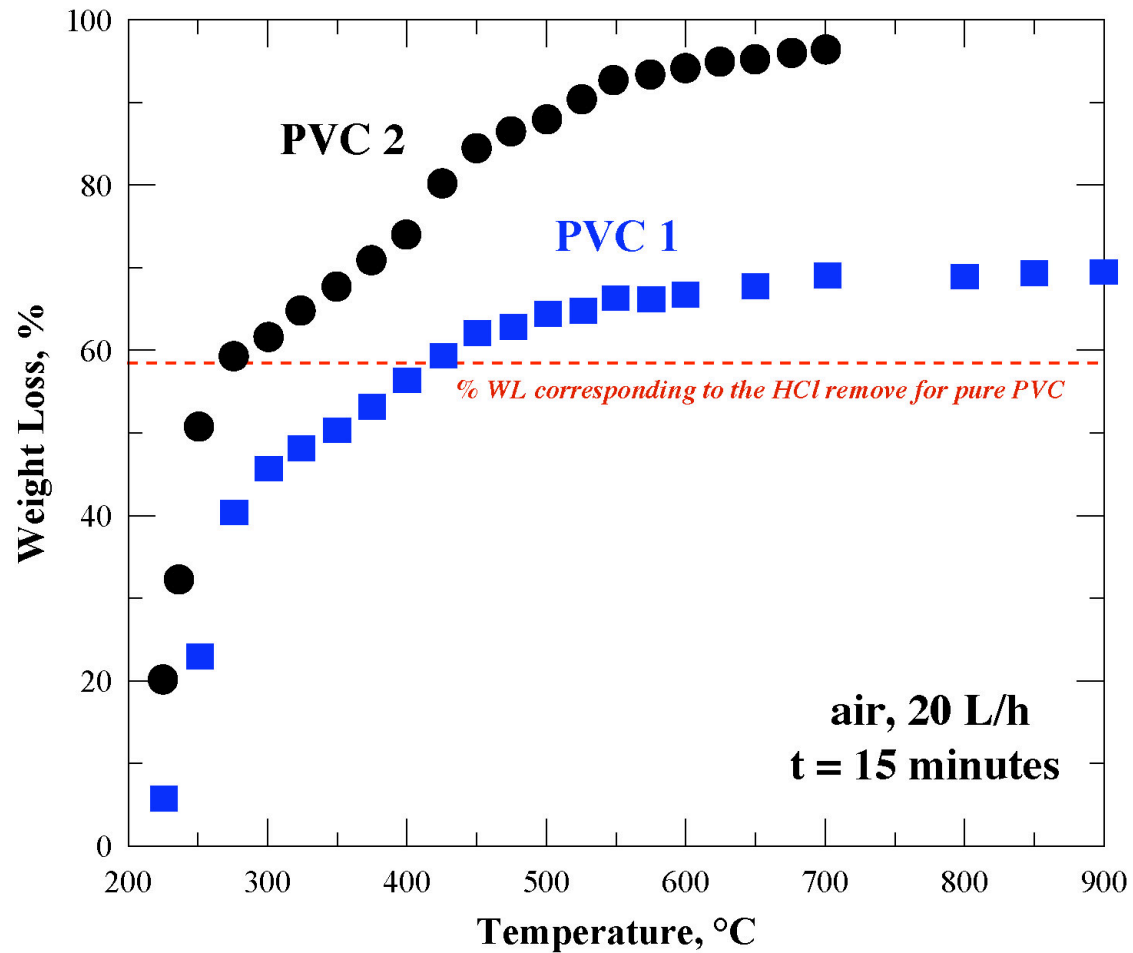
P1 light



P1 dense

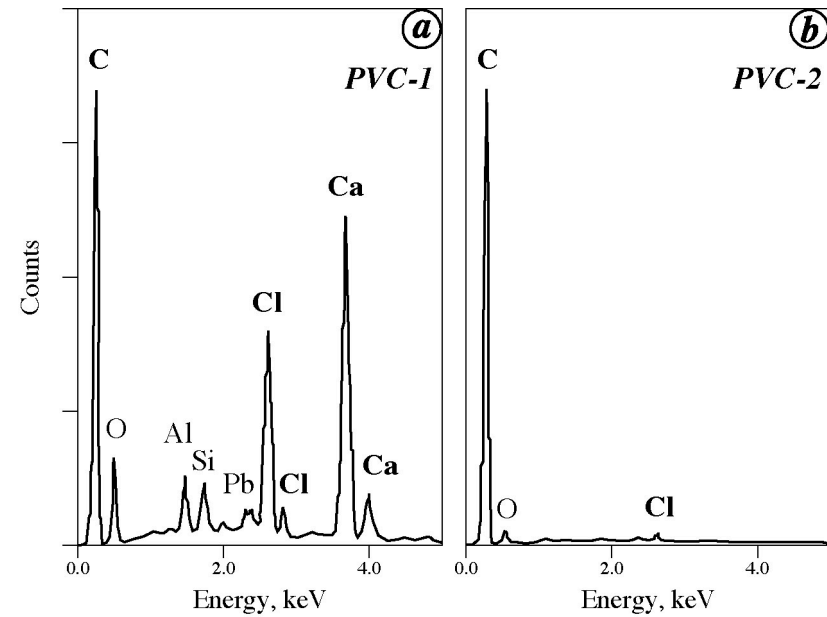
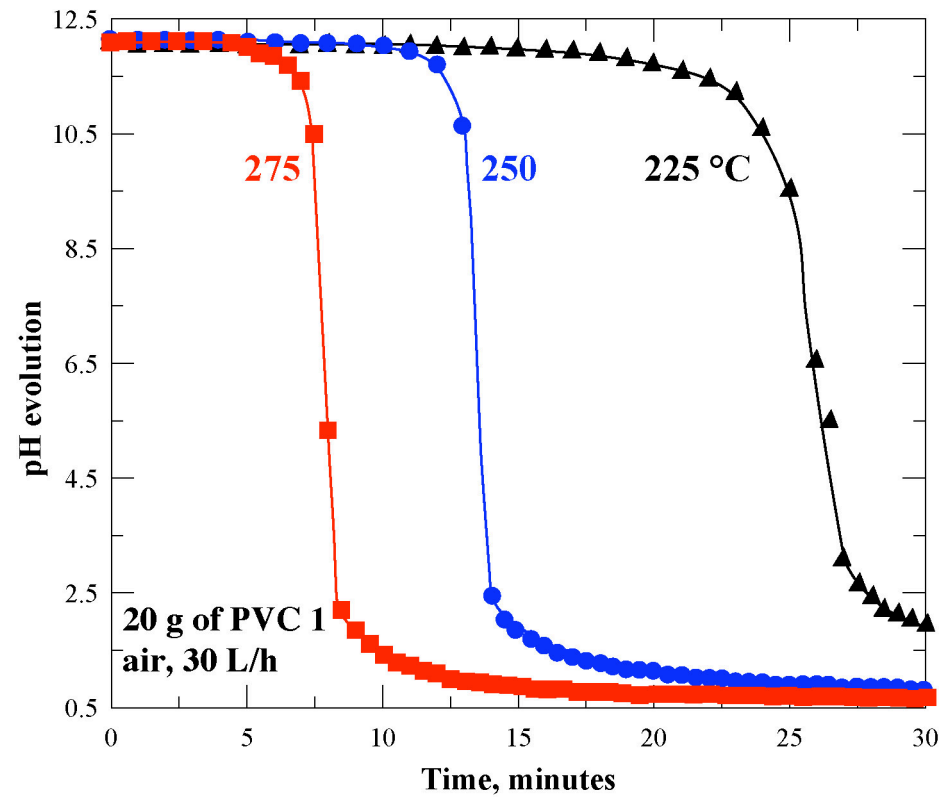
Thermal Treatment of the PVC Samples

Horizontal Furnace



PVC Dechlorination at 225 - 275 °C

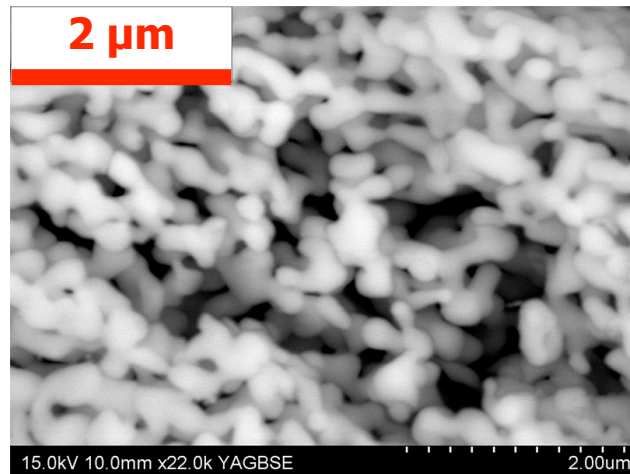
Evolution of the pH during PVC-1 treatment



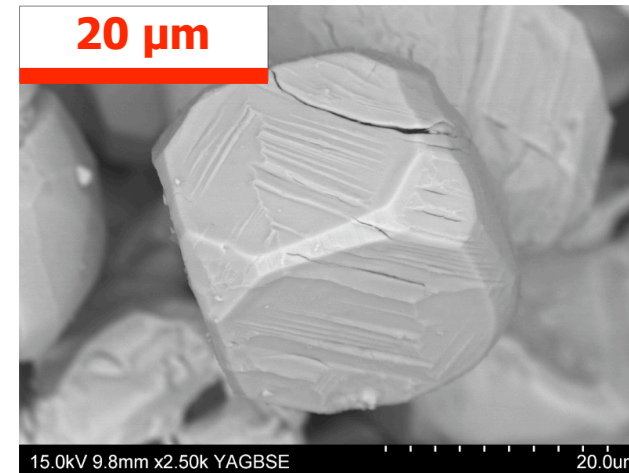
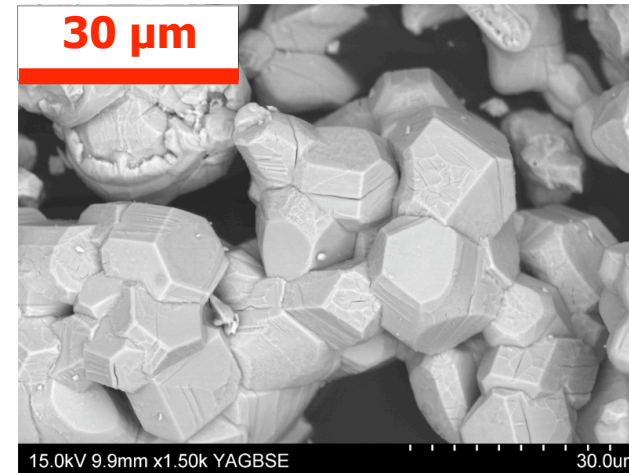
Crystal Growth during Thermal Treatment

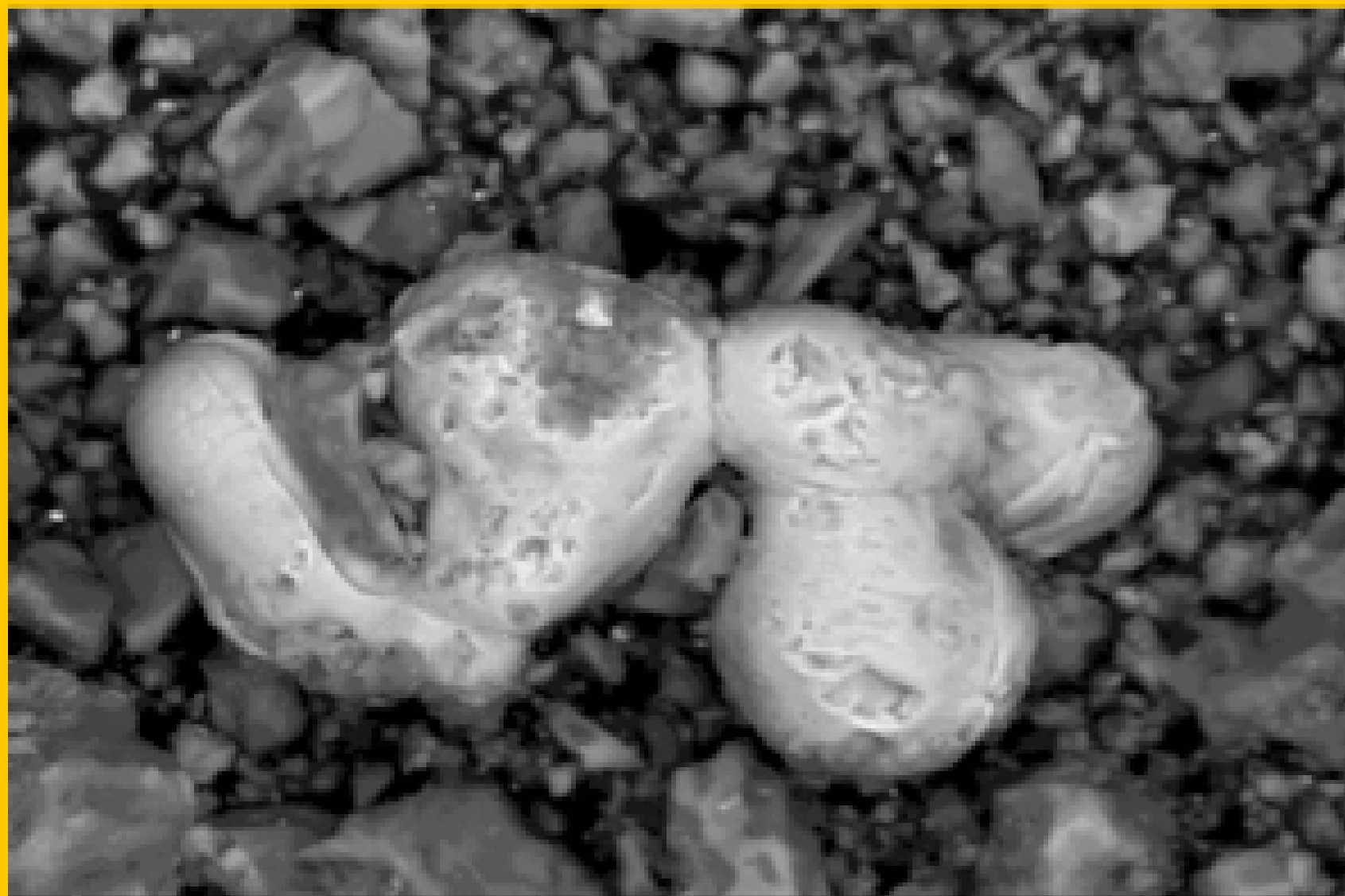
SEM Aspects

**Hematite
Initial Sample**



**Hematite+PVC
Heated at 1025 °C**



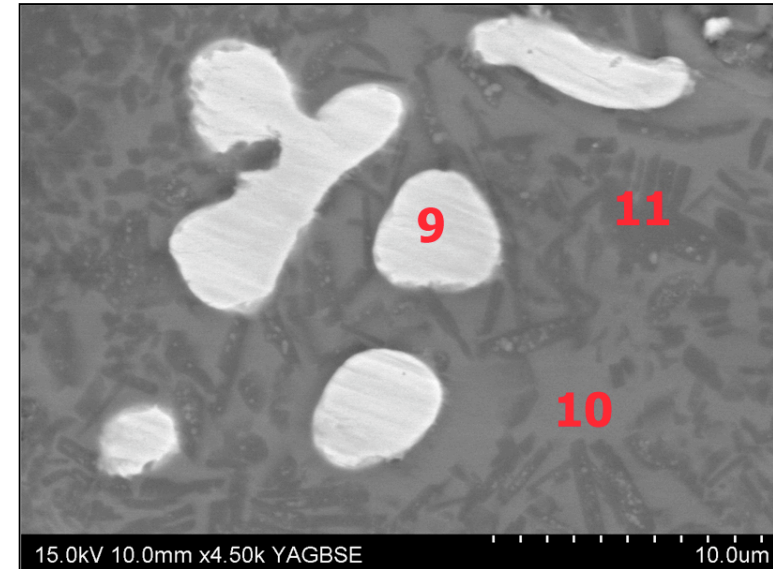
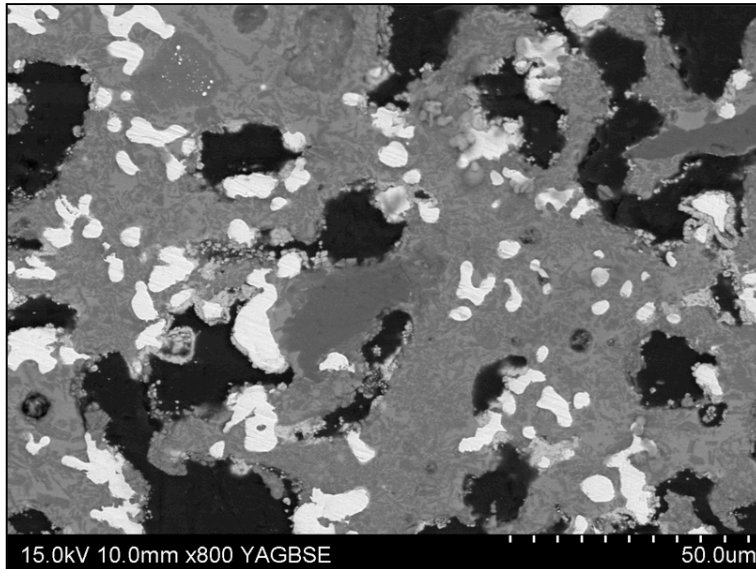


15.0kV 10.0mm x3.00k YAGBSE

10.0um

Reduction of Fe_2O_3 by PVC (in presence of O_2)

SEM Observation (polished section)

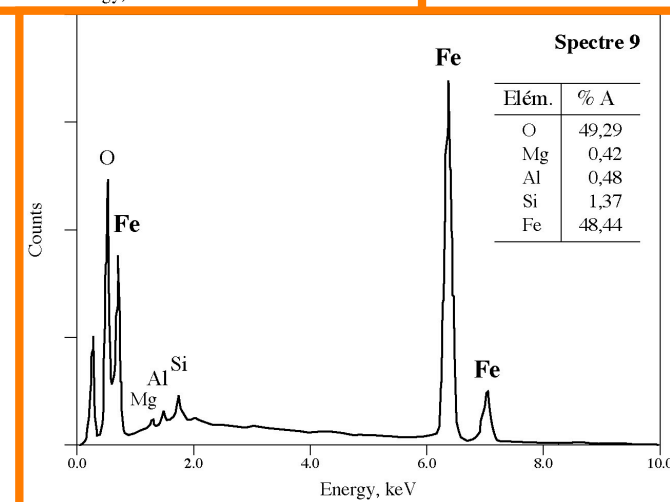
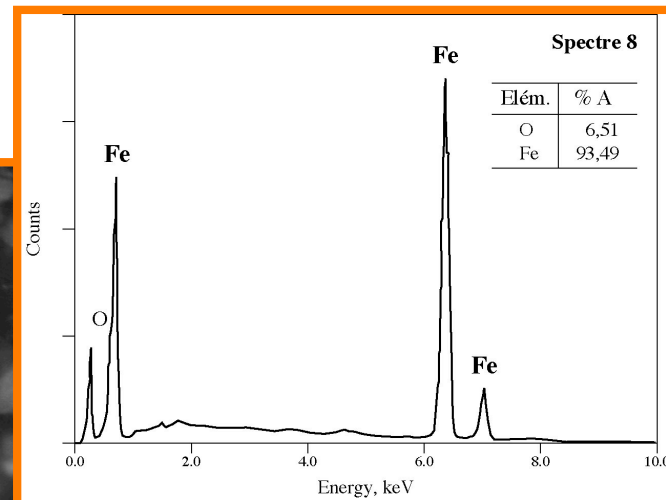
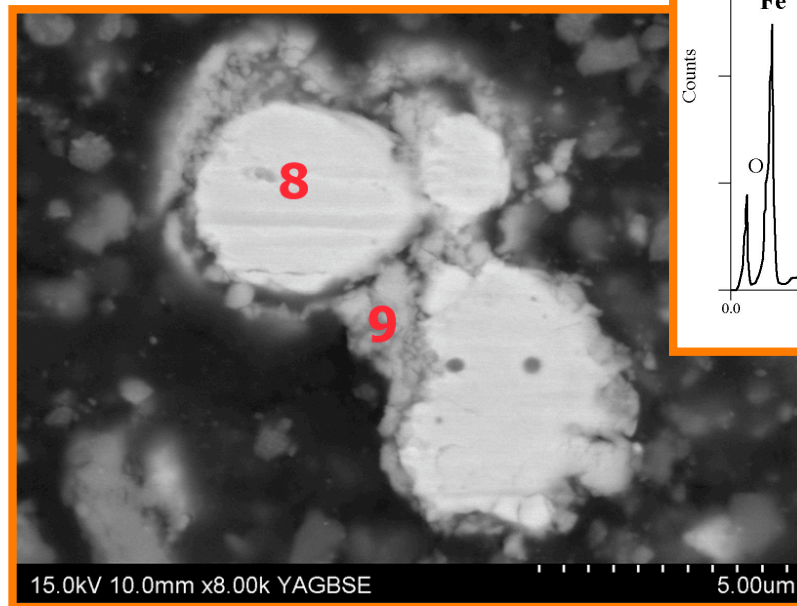


SEM-EDS results (*atomic %*)

	O	Al	Si	Cl	Ca	Fe
Spot 9	4.94					95.06
Spot 10	53.74	5.66	25.79	0.51	6.36	7.93
Spot 11	55.42	15.34	19.56		8.46	1.22

Reduction of Fe_2O_3 by ASR

T = 1050 °C



Application example : Pilot scale at ArcelorMittal

6t Electric Arc Furnace. 10% energetic gain



Conclusions

Multi-parametric analysis of the thermodynamic and experimental use of residual plastics as a substitute of energetic material and reducing agent in metallurgy of iron proves the feasibility.

Physical separation methods may increase the iron content in mineral fraction.

The tramp elements (Cl, Pb, Zn, Cu) can be separated by floating and/or low temperature treatment of residual plastics. Tests have been carried on in an electric furnace pilot plant.