Electron microscopy investigation on Pt deposited on different carbon nanostructures for fuel cell applications

D. Mirabile Gattia[1], M.Vittori Antisari[1], L. Giorgi[1], R. Marazzi[1], E. Piscopiello[2], A. Montone[1], S. Bellitto[3], S. Licoccia[3], E. Traversa[3]

1. FIM Department, ENEA - C.R. Casaccia, Via Anguillarese 301, 00123, Rome, Italy
2. FIM Department, ENEA C.R. Brindisi, Via Appia Km 702, 72100 Brindisi, Italy
3. Department of Chemical Science and Technology, University of Roma "Tor Vergata", Via della Ricerca Scientifica, 00133, Rome, Italy

vittori@enea.it
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Nanometric noble metal particles are largely used for catalysis applications. In the technology of Polymeric Membrane Fuel Cells (PEM) and Direct Methanol Fuel Cells (DMFC), catalyst particles supported on porous carbonaceous materials, like carbon black, are used to realize both the anode and the cathode. The supporting material on which the nanoparticles are homogenously dispersed has the role of providing a large amount of triple points, among catalyst, electron conductive carbon material and the ion conductive polymer, where the anode and cathode reaction can occur.

Recently carbon nanotubes have been used as support material for preparing electrodes. The resulting enhanced electrochemical performances, with respect to conventional electrodes using carbon black, have been correlated to higher electronic conductivity and better resistance to electrochemical oxidation [1]. Moreover also the recently discovered single-wall carbon nanohorns (SWNH) [2], have demonstrated to suitably support Pt and PtRu particles [3].

In this work, Pt particles have been deposited by an impregnation method on three different carbon supports: Multi-Wall Carbon Nanotubes (MWNT), SWNH, prepared in our laboratory by arc discharge [4,5], and Vulcan-XC72 carbon black purchased from ETEK. Scanning and transmission electron microscopy, besides X-Ray diffraction, have been used to determine the structural features of the composites to be correlated with the electrochemical performances. To this purpose, cyclic voltammetry has been used to evaluate the electrochemical active surface area (EAS) and the mass activity toward the methanol oxidation reaction.

Electron microscopy revealed that the shape of the Pt particles depends on the nature of the carbon support (Figure 1). Classical equi-axed particles are observed on Vulcan XC-72 while particles aggregates, formed by elongated particles a few nanometers in diameter, have been found on SWNH and MWNT. The agglomerates have a size in the 50 - 100 nm range in the case of SWNH sample and in the range 20 to 50 nm for the MWNT

Electrochemical measurements performed by cyclic voltammetry show that the aggregation has a double effect on the electrochemical performances. From one side it reduces the active surface area, while it increases the specific mass activity toward methanol oxidation reaction at least in the case of MWNT (Figure 1d). Even if the interpretation of the electrochemical behavior on the basis of the sample microstructure is not completely satisfying, we have shown that some features of the catalyst particles, like shape and presence of defects like grain boundaries, can have an important effect on the performances in specific applications related to the fuel cell technology.

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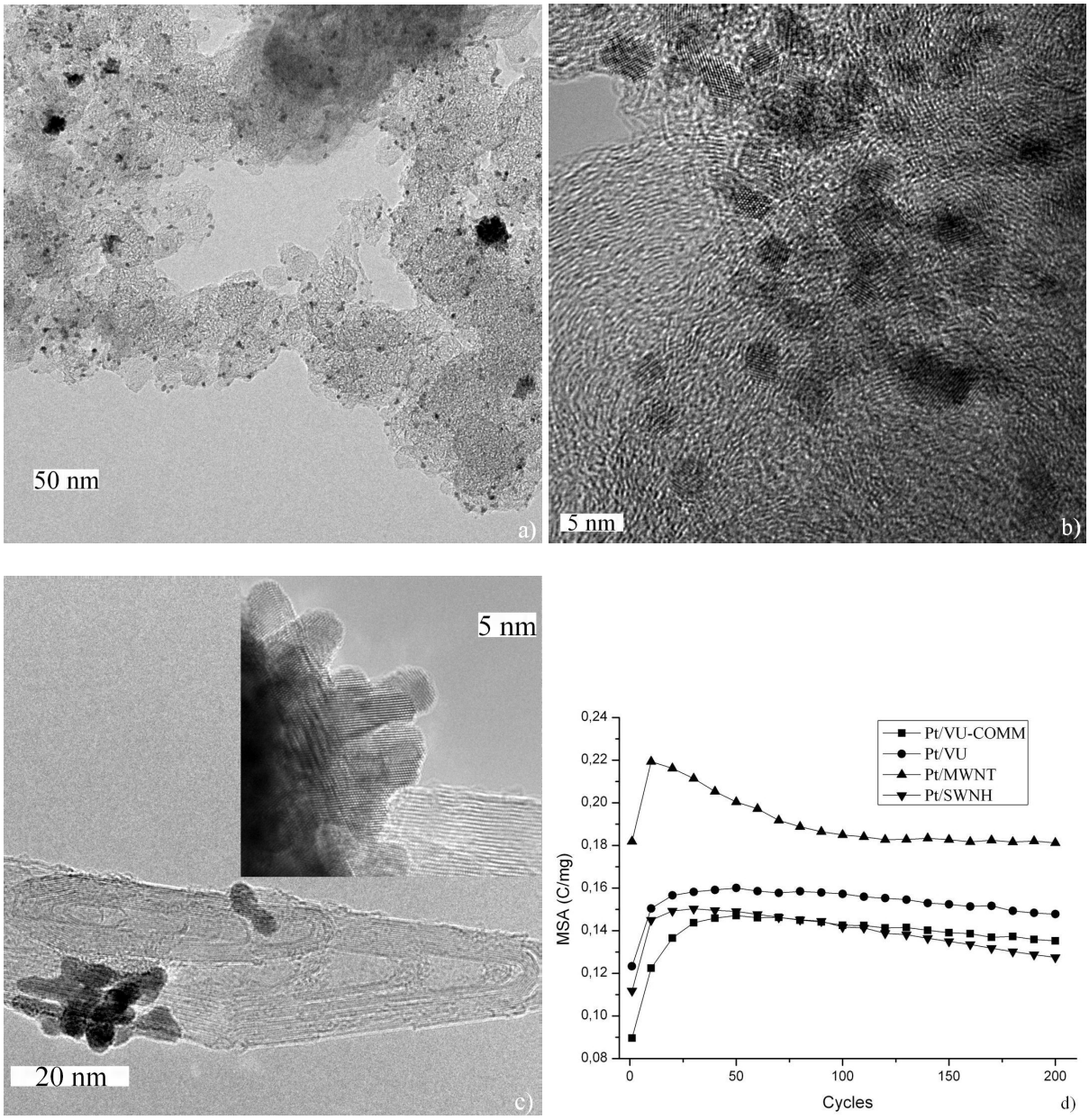

Figure 1. a), b) and c) Pt particles and aggregates deposited on SWNH, Vulcan XC-72 and MWNT respectively. In the inlet in c) an image of Pt aggregates at lattice resolution is reported. In d) the mass specific activity of Pt/C samples in function of the number of cycles of potential sweeps in 1M H_2SO_4 solution + 0.5 M CH_3OH at 30°C is showed.