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Importance of Porosity Control in Active Carbon Blocks for Process Water Treatment

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Water is probably one of the most common ingredient in prepared foods and beverages: biscuits, pastas, cakes, soups, juices, all soft drinks and most of alcoholic ones, just to cite the commonest.
The constancy in quality and organoleptic characteristics is a very important factor for the market success of industrial food products.
Water is not only H2O, but also a very complex mix of micro ingredients, mainly natural salts, but also disinfectants (as chlorine) or polluting agents, sometimes dangerous for human health. Water changes from country to country, it is different from mountain to the plain, from the north to the south.
Anyway, just only chlorine and variable salt content affect the water quality and its organoleptic characteristic.Therefore, in a standardised industrial production the quality control must include also water.
Reverse Osmosys (RO) membranes (born in the 50ies during Korean war to help American soldiers to purify the terrific jungle water) has been the first industrial approach in this sense; but, just because RO systems removes around 95% of total dissolved salts, the taste of water is somewhat poor.
In the last decade new micro- and ultra-filtration technics have been developed, also for removing heavy metals from drinking water (Chang Q. et al. and Derylo-Marczewska et al.); one important component of such filters is the carbon-block (CB), extruded or synterised active carbon mixed with a plastic polymer under the action of a catalyser (Hines D. et al.); the shape is a hollow cylinder and the permeation of water is from outside to inside, through the cylinder walls.
The porosity and the control of pore structure of the walls (or degree of filtration) condition the performance of the filter (Kyotani T.).
The aim of this research is to identify a suitable and reliable analytical method in order to compare Think Water's carbonblocks to other present on the market, and to manage production process parameters.

1. Materials and methods

All the samples of carbon block have been obtained by means extrusion: this process is in general preferred because it is a continuous one and allows changing the parameters during the production.
Sample A (code 1100-549) is coming from a worldwide leading company, Matrix Separations, LLC (6000 Century Oaks Drive, Chattanouga, TN, USA); sample B (code 2065-5) is produced by one of the most important European ones, Afimo (Rue de Gabian, 1, Principate de Monaco) ; sample TW is produced at Think Water facilities.
Porosity analysis were run by means a SEM (scansion electronic microscope) Quanta 200 (FEI, Hillsboro, Oregon, USA), after sputter coating, in high vacuum conditions and BSE (back scattered electron) image signal (Cardell C. et al.), at 20 kV energy level.
An imagine analyser was used connected to SEM. All the analytical equipment are at DiBEST laboratories of Calabria University.

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2. Results and discussion

The following figure (1) shows a general surfacial overview of the reference samples A, B and TW.

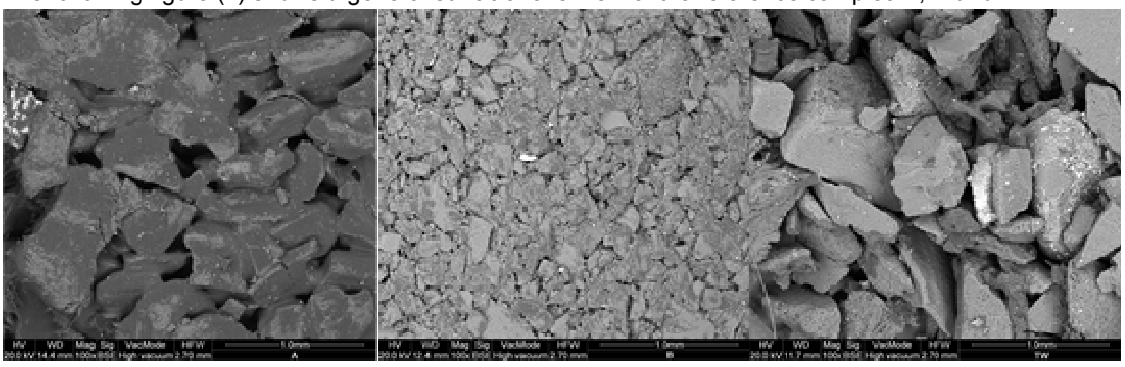
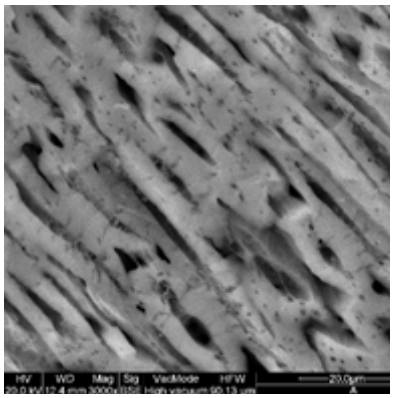


Figure 1- surface view

It is possible to note that A and TW seem to be produced starting from carbon granules of higher granularity and, furthermore, sample B could have a formulation with higher binding agent.
The pictures and relative porosity analysis of A, B and TW samples are reported in figures 2, 3 and 4 and tables 1, 2 and 3. In spite of the surfacial aspect, it is possible to see that sample A is the less homogenous one, with a degree of filtration ranging from 1.9 to 8.3 micron; B and TW, otherwise, are really very similar, ranging from 1.7 to 3.8 micron and 1.5 to 3.9 respectively



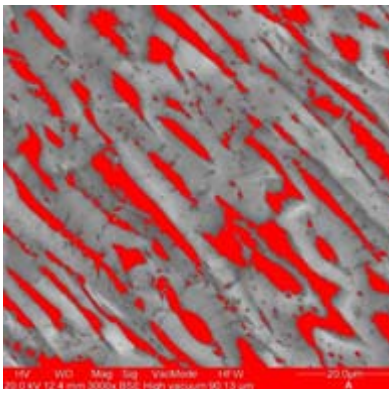


Figure 2 *Sample A* *Slice A* *Drawing A*

Table1: Analysis sample A
Analysis-1 A

Slice	Total Area	Average Size	%Area	Major (µm)	Minor (µm)
	1.700.939	18.488	16.854	8.373	2.141

Analysis-2 A

Slice	Total Area	Average Size	%Area	Major (µm)	Minor (µm)
	2.233.281	12.835	22.128	4.750	2.148

Analysis-3 A

Slice	Total Area	Average Size	%Area	Major (µm)	Minor (µm)
	1.719.981	9.100	17.081	4.267	1.958

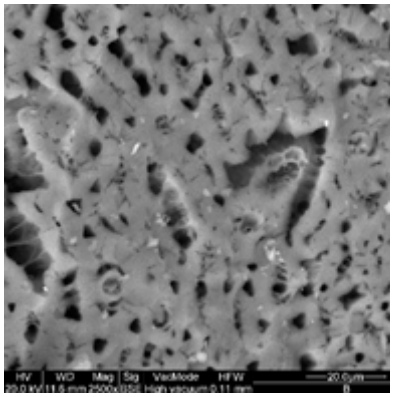
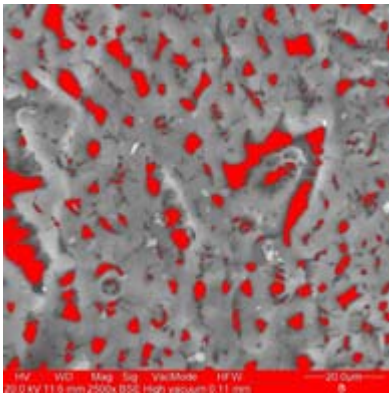
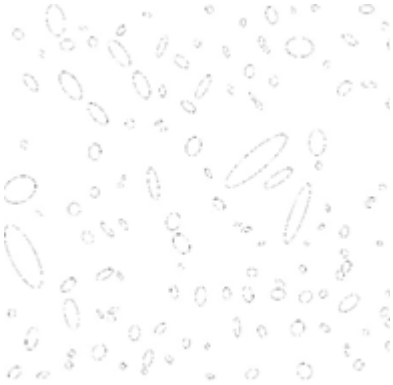




Figure 3 *Sample B* *Slice B* 3 *Drawing B*

Table 2: Analysis sample B

Analysis-1 B

Slice	Total Area	Average Size	%Area	Major (μm)	Minor (μm)
	1.176.981	4.598	11.658	2.852	1.735

Analysis-2 B

Slice	Total Area	Average Size	%Area	Major (μm)	Minor (μm)
	1.371.163	6.348	13.555	3.255	1.862

Analysis-3 B

Slice	Total Area	Average Size	%Area	Major (μm)	Minor (μm)
	1.538.751	8.185	15.212	3.835	1.987

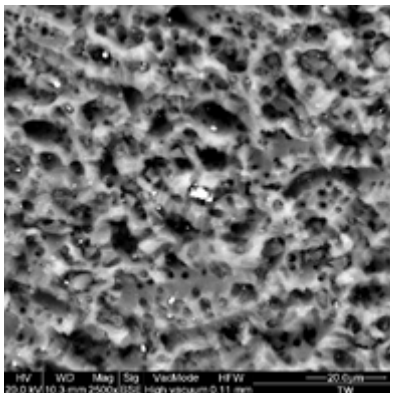
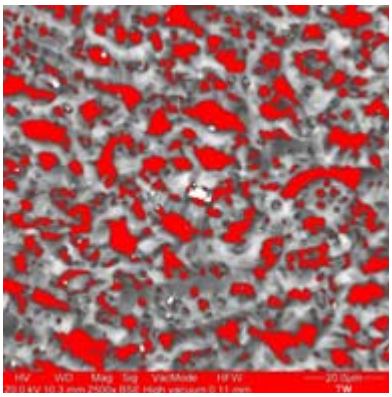
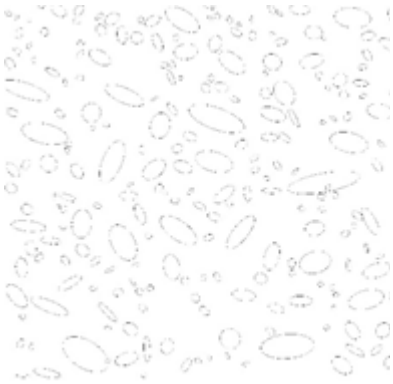




Figure 4 *Sample TW* *Slice TW* *Drawing TW*

Table 3: Analysis Sample TW

Analysis-1 TW

Slice	Total Area	Average Size	%Area	Major (μm)	Minor (μm)
	570.244	4.713	5.600	3.110	1.569

Analysis-2 TW

Slice	Total Area	Average Size	%Area	Major (μm)	Minor (μm)
	2.252.190	8.798	22.302	3.852	2.097

Analysis-3 TW

Slice	Total Area	Average Size	%Area	Major (μm)	Minor (μm)
	1.978.370	9.421	19.558	3.964	2.106

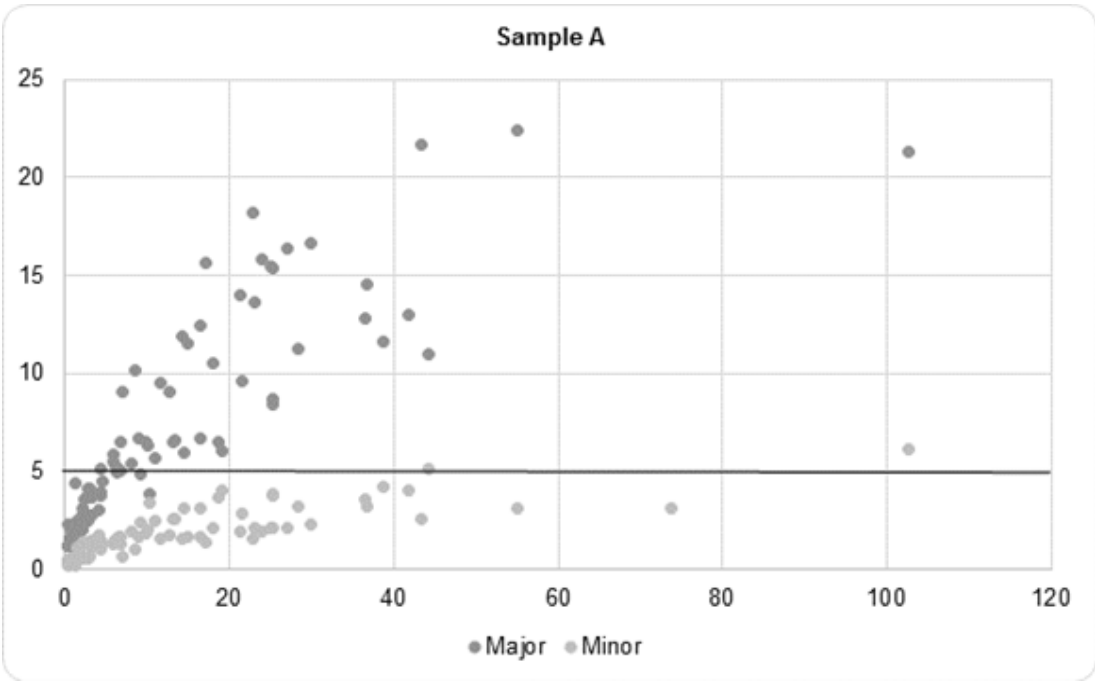


Figure 5: holes dimension distribution Sample A

The orientation of carbon fibers in sample A may also suggest different extrusion conditions, maybe with a higher shear stress that leads to an elongation of the same fibers and a consequent variation of porosity distribution. In the following graphics holes distribution is showed, related to the surface “observed” during the scansions; for each scansion the SEM-BSE equipment points out a larger (dark grey) and a smaller (clear grey) hole (see figures 5, 6 and 7). As noticed before, sample A has a great number of holes higher than 5 microns, while B and TW have a similar majority of holes under 5 microns. This means a higher efficiency of filtration without problems of charge losses; in fact, they may occur in presence of porosity lower than 1 micron.

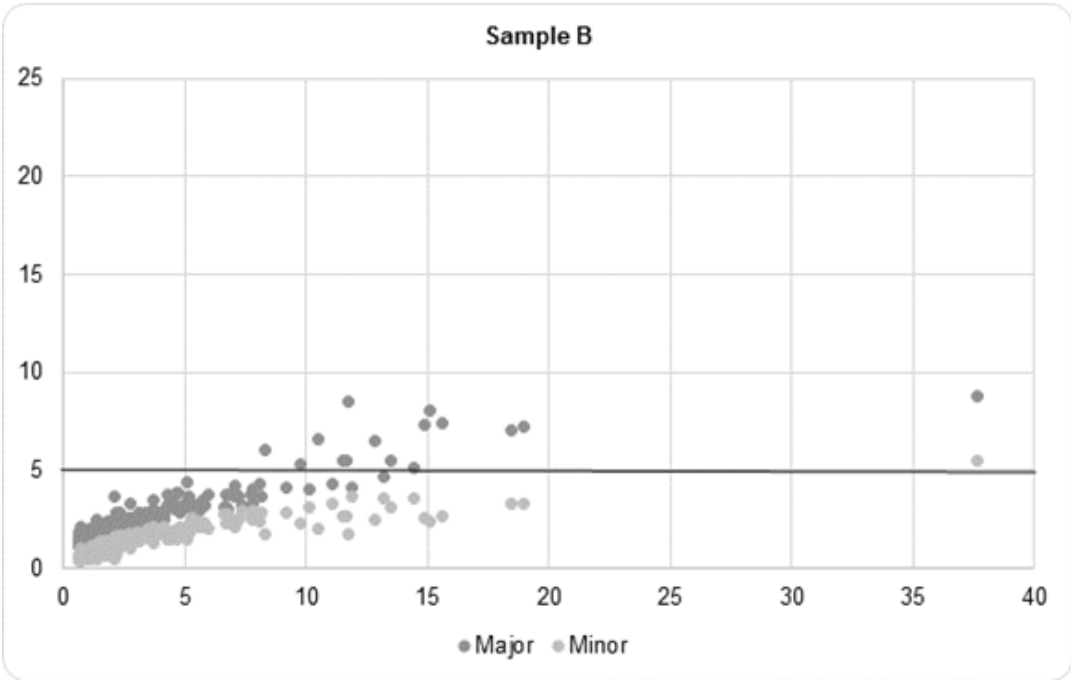


Figure 6: holes dimension distribution Sample B

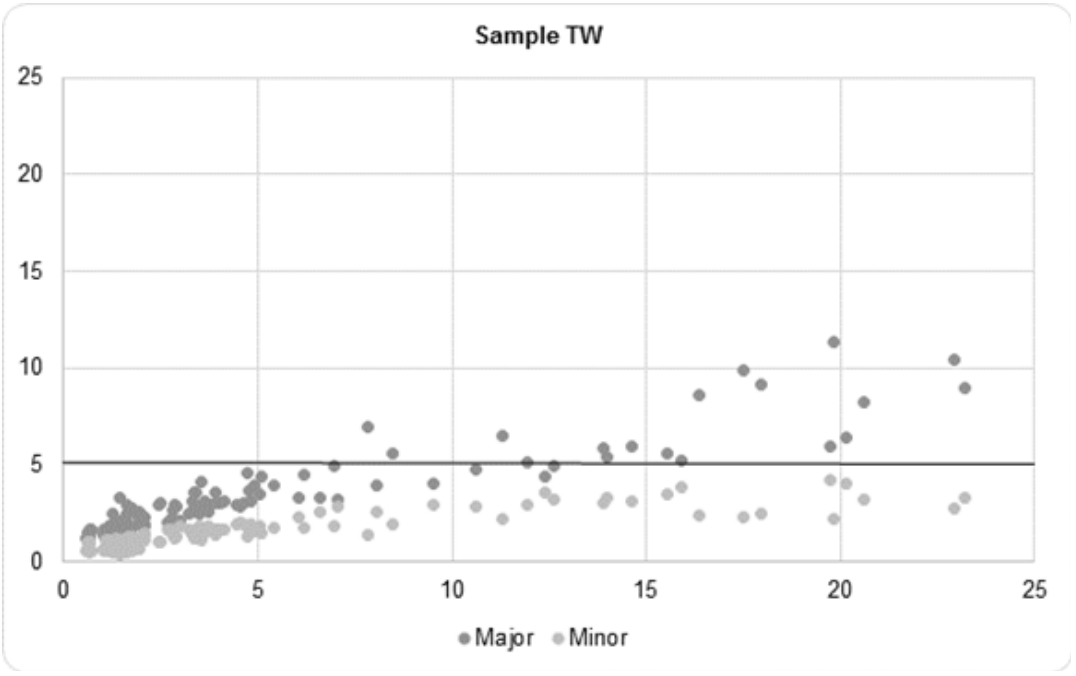


Figure 7: holes dimension distribution Sample TW

3. Conclusions

The SEM-BSE image analyser demonstrated to be an efficient and reliable method in order to determinate very precisely the degree of filtration of carbon blocks and, generally speaking, of every filtering solid substrate. The obtained information are not only useful by a pure analytical point of view, but also in order to evaluate raw materials typologies, to formulate hypothesis upon recipes constitution, to understand the production process and to set up the related technological parameters.
Obviously, SEM-BSE could be very useful as a quality control system, but the cost of the analysis is rather high; a good compromise should be to run daily tests by means a particle detector on the filtered water and a periodic check by SEM- BSE equipment.

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