Emerging pollutants and managing wastewater and waste

PFAS removal from water using zeolites: material characterization and application on PFAS-contaminated water samples

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Zeolites are crystalline microporous materials characterized by connected tetrahedra (usually Si, Al linked to oxygen atoms) that form three-dimensional (3D) networks of pores, cages, and channels [1]. The aim of the study is to explore **zeolites** differing for structure, polarity, and pore and channels geometry (Fig.1). Materials were tested for PFAS adsorption from water [2] among **18 short- and long-chain PFAS solution** (Fig.2) **and four fortified PFAS contaminated real water samples: RW1-F (raw water of drinking water plant), RW2-F (wastewater of wastewater plant), RW3A-F (landfill leachate), RW3B-F (landfill groundwater)** (Fig.3-4). Powdered activated carbon (PAC) was tested at the same conditions for comparison. X-ray powder diffraction (Fig.4) and thermal analysis (Fig,5) were used to assets materials features.

Fig.1 PAC PULLSORB was purchased from CalgonCarbon. Beta* zeolites were calcined.

Sample	Supplier and product code	SiO_2/Al_2O_3 mole ratio	Surface Area (BET, m^2/g)	Nominal cation form
BETA25* (BEA)	Zeolyst International CP814E*	25	680	Ammonium
BETA360* (BEA)	Zeolyst International CP811C*300	300	620	Hydrogen
Y720 (FAU)	Zeolyst International CBV720	30	780	Hydrogen
Y760 (FAU)	Zeolyst International CBV760	60	720	Hydrogen
Y390 (FAU)	Tosoh Corporation HSZ390HUA	500	630	Hydrogen
MOR (MOR)	Tosoh Corporation 690HUA	240	450	Hydrogen
L (LTL)	Tosoh Corporation 500KOA	6.1	290	Potassium
F2H45 F4H45 (FAU –KFI)	Synthetized zeolites from coal fly ash [3]	NAT-CHA (CHA)	Natural Chabasite (65%wt. Chabasite) Zeolite Italia	

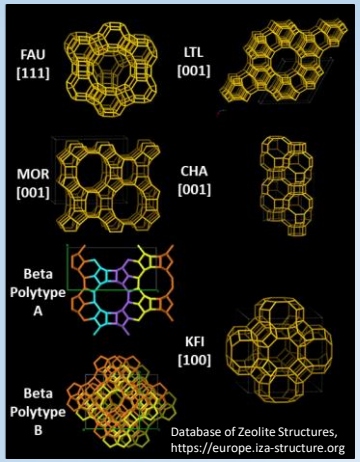


Fig.2 18PFAS solution batch adsorption test results (0-24h, 1:2 ratio).

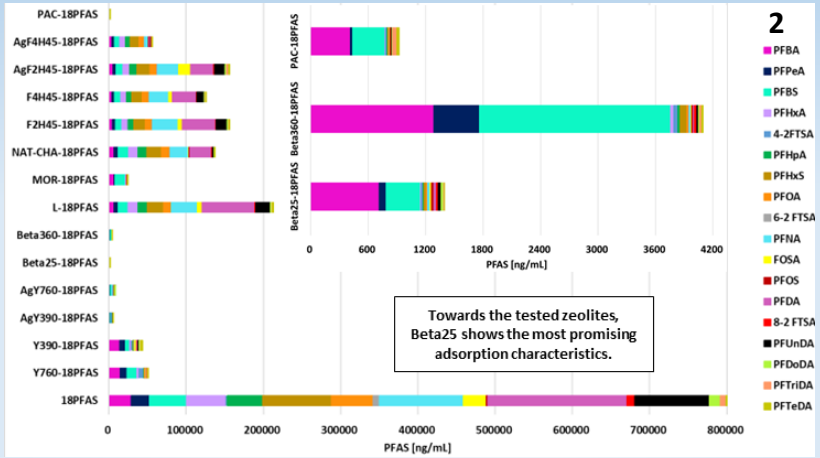
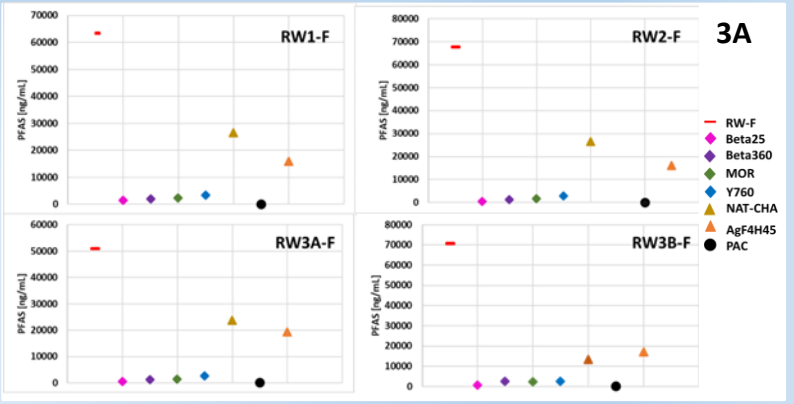
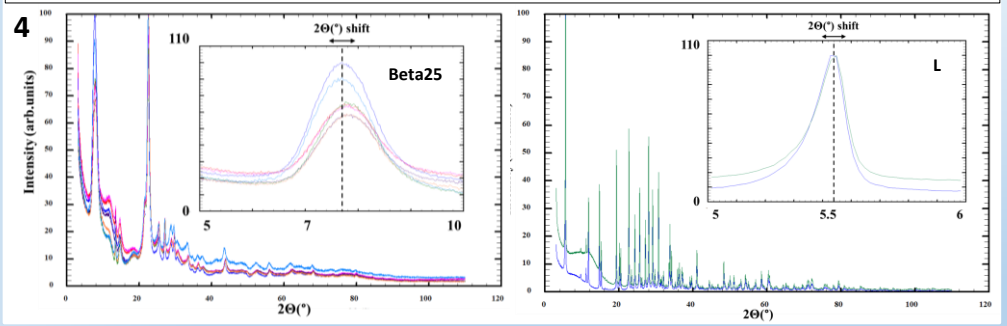


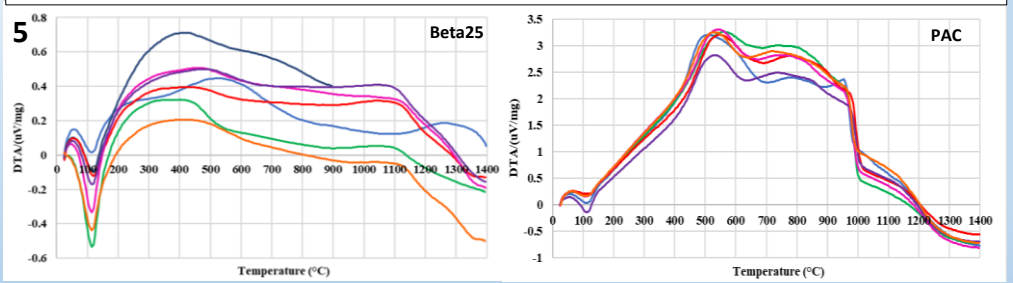
Fig.3 A,B Fortified real water samples batch test results (0-24h, 1:2 ratio).



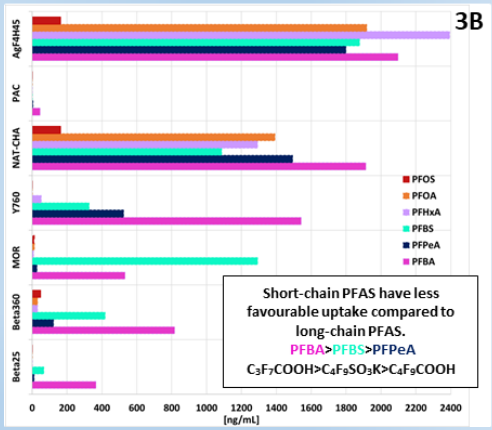
Beta25 patterns show lattice modification between bare and PFAS loaded samples. Towards the tested materials, L zeolite diffractograms are the most unaltered.



Thermal analyses show that PFAS are expelled from ~ 300°C up to ~700°C and some trapped carbonaceous materials can be degraded until 1400°C. Due to the thermal stability, zeolites offer the possibility of thermal treatments regeneration.



bare sample; 18PFAS; RW1-F; RW2-F; RW3A-F; RW3B-F.



Zeolites uptake is not subject to competitive species present in the real water samples. The removal is promising at high and low concentrations of PFAS for all the samples except the L (LTL) zeolite. Calcined hydrophobic **Beta25 zeolite, exhibit improved adsorption reaction rate and selectivity**; and compared to PAC zeolites **regeneration via thermal treatment is possible**.

References: [1] McCusker L.B., Baerlocher C., (2001). In: van H. Bekkum, E. M. Flanigen, P. A. Jacobs, J. C. Jansen, Elsevier. Introduction to zeolite science and practice, 3, 37 [2] J. Gluge, M. Scheringer, I.T. Cousins, J.C. DeWitt, G. Goldenman, D. Herzke, R. Lohmann, C.A. Ng, X. Trieri and Z. Wangj, An overview of the uses of per- and polyfluoroalkyl substances (PFAS), Environ. Sci. Processes Impacts, 2020, 22, 2345-2373. [3] Belviso C., Cavalcante F., Fiore S., (2010) Synthesis of zeolite from Italian coal fly ash: Differences in crystallization temperature using seawater instead of distilled water, Waste Man., 30, 5, 839-847.

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