Article

Combination NIPS/TIPS Synthesis of α-Fe_2O_3 and α/γ-Fe_2O_3 doped PVDF Composite for Efficient Piezocatalytic Degradation of Rhodamine B

A.G. Magomedova [1], A.A. Rabadanova [1], A.O. Shuaibov [1], D.A. Selimov [1], D.S. Sobola [2,*], K. Rabadanov [2], K.M. Giraev [1] and F.F. Orudzhev [1,3,*]

[1] Smart Materials laboratory, Department of Inorganic Chemistry and Chemical Ecology, Dagestan State University, St. M. Gadjieva 43-a, Dagestan Republic, 367015 Makhachkala, Russia
[2] Department of Physics, Faculty of Electrical Engineering and Communication, Brno University of Technology, Technicka 10, 616 00 Brno, Czech Republic
[3] Amirkhanov Institute of Physics of Dagestan Federal Research Center, Russian Academy of Sciences, 367003 Makhachkala, Russia
* Correspondence: farid-stkha@mail.ru

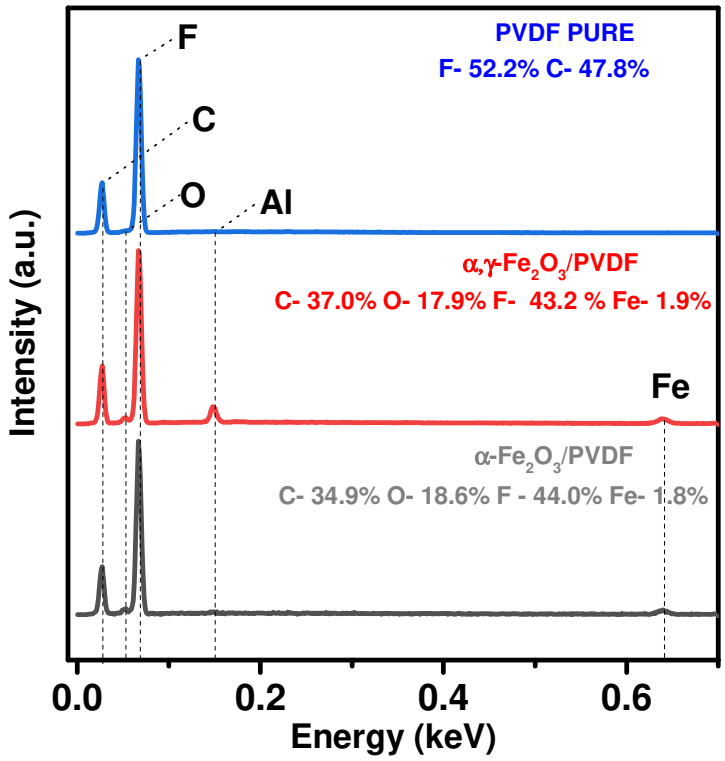

Figure S1. EDX spectra of samples

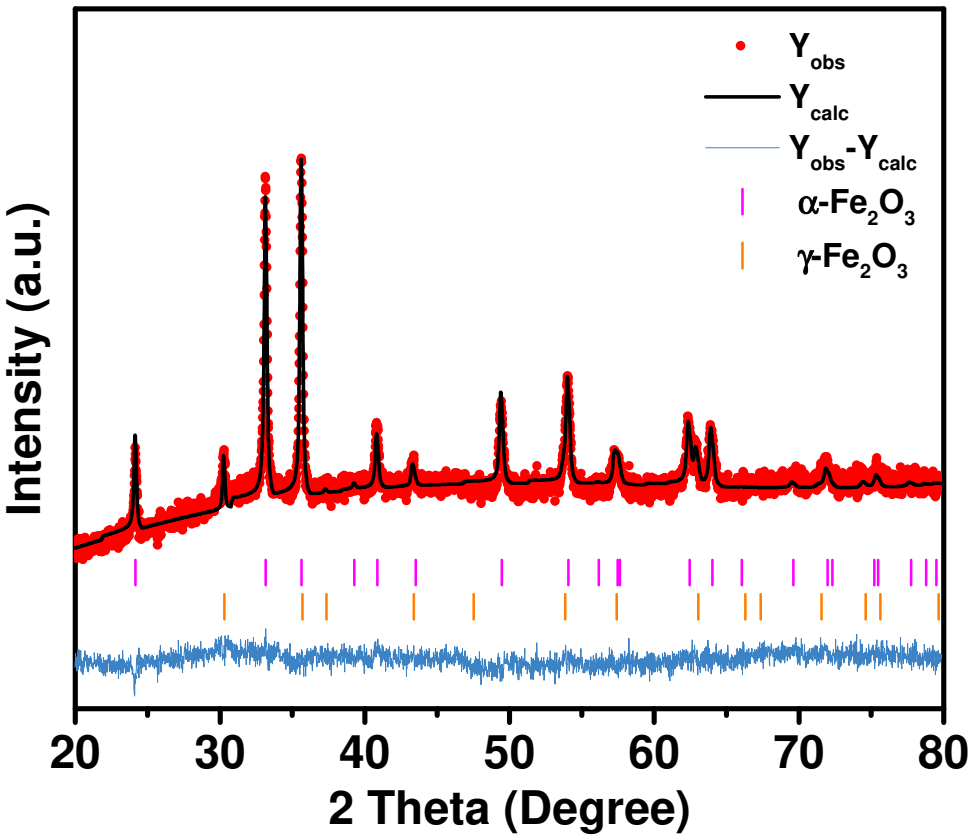

Figure S2. XRD patterns of α-Fe2O3 and α,g-Fe2O3 with standarts.

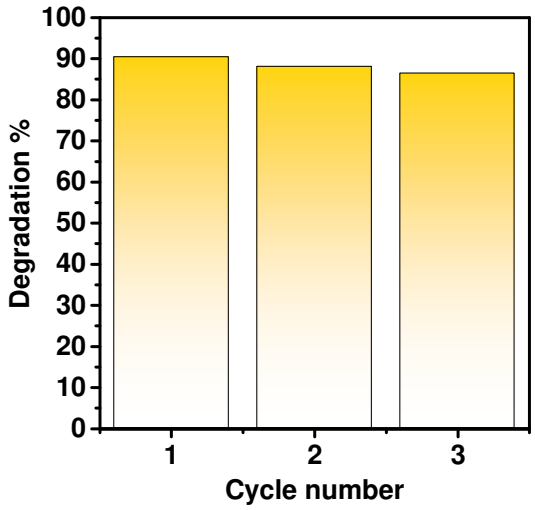

Figure S3. Cycling tests of the α-Fe2O3/PVDF membrane in the degradation of RhB.

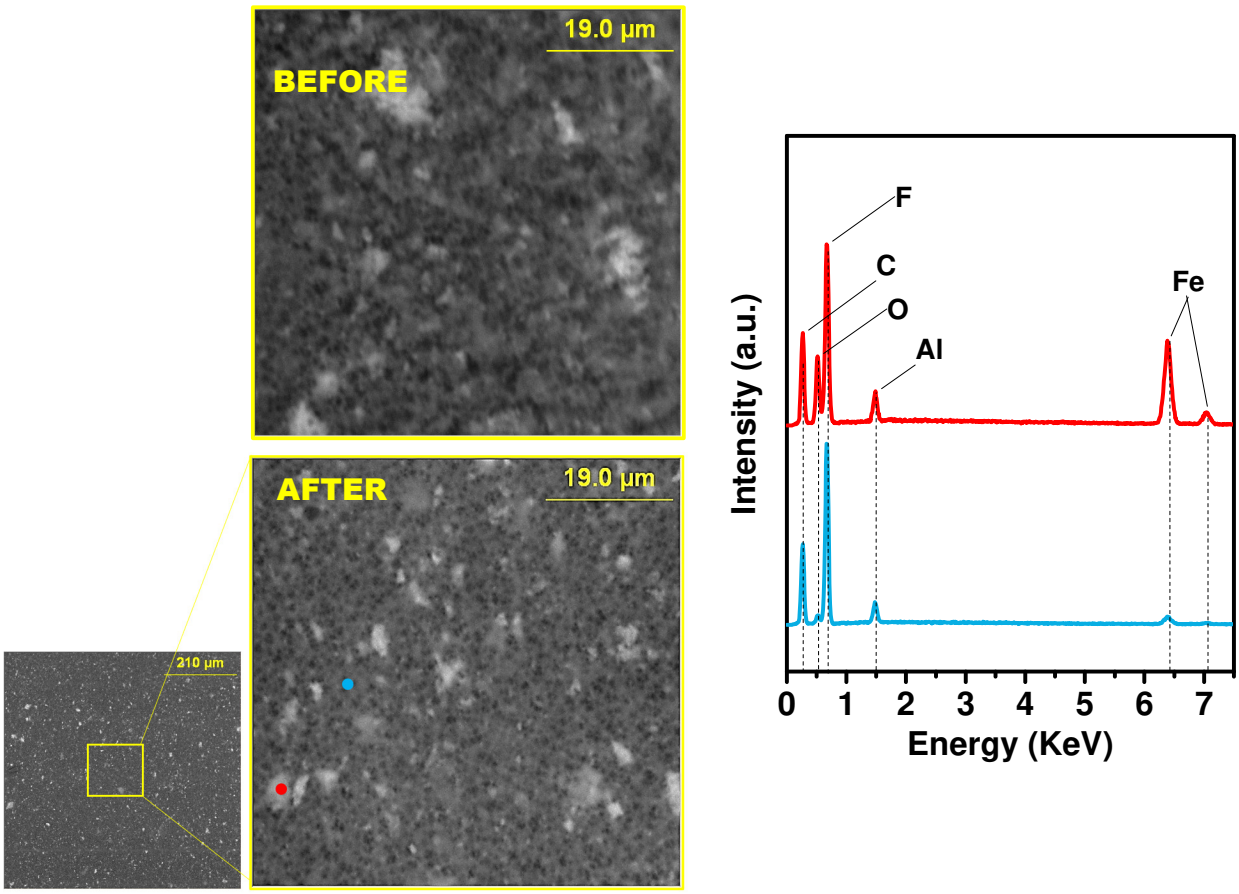

Figure S4. SEM images of α-Fe_2O_3/PVDF before and after 3 cycles piezocatalytic experiment and selected area EDX spectra

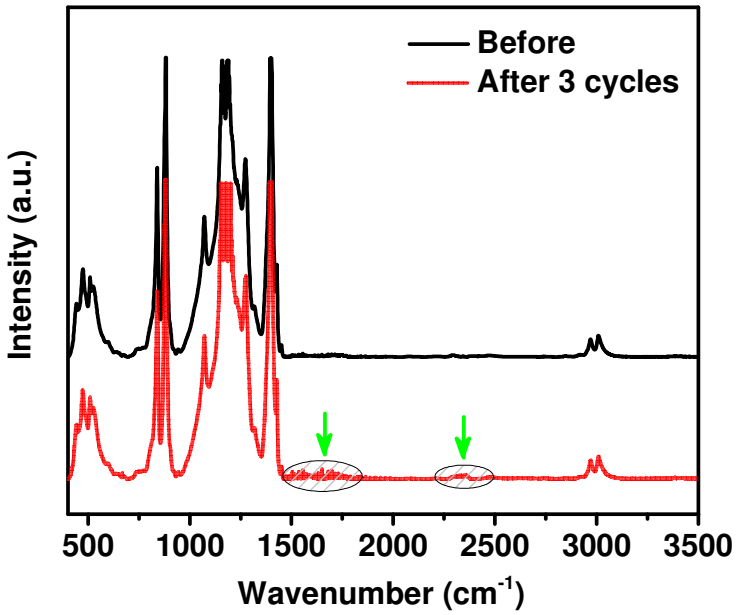

Figure S5. FTIR spectra of α-Fe_2O_3/PVDF before and after 3 cycles piezocatalytic experiment.

Table. S1. Previously reported work and its comparison with our present work in field Piezocatalytic properties of PVDF based composites.

Materials	Pollutants	Time (min)	Mechanical source	Degradation, %	Rate constant, min^{-1}	References
E-MoS_2/PVDF EFMs 10 wt % 100 mg	OTC C= 20 mg/L V= 100 mL	24	US v= 20 kHz	93.05	0.09124	1
Ag@$LiNbO_3$/PVDF 5 wt % 2.5 cm Diameter	Rhodamine B C= 5 mg/L V= 10 mL	120	Ultrasonicator W= 70 W v= 40 kHz	~80	-	2
CBO/PVDF (1:1 mass) ?	Rhodamine B C=10 $mg{\cdot}L^{-1}$ V=?	10	Ultrasonic instrument W = 100 W	99.9	-	3
MoS_2-PVDF 10 wt% 2×2 cm^2 thickness 50 μm	Rhodamine B C= 10 ppm V= 10 mL	20	RS Pro Ultrasonic Cleaner W=100 W	>90	0.21	4
PVDF/$ZnSnO_3$/MoS_2 20 wt % ?	MB C= 5 mg/L V=?	4	Ultrasonicator W= 50 W v= 40 kHz	100	-	5
BTO-PDMS (25 wt %) ?	Rhodamine B C= 5 mg/L V= 40 mL	120	Ultrasonic machine W= 400W v= 40 kHz	~94	0.02254	6
CNT/PVDF (SCP, 0.015 g)	Rhodamine B C= 5 mg/L V= 15 mL	120	US W= 240 W	≥ 95	-	7
$Bi_2ZnB_2O_7$ - Polyacrylonitrile (BBZO-PAN)	MB C= 5 mg/L V= 10 mL	180	Ultrasonicator (Labman) W=150 W v= 40 kHz	37	$2.1*10^{-3}$	8

1.5×1.5 cm^2						
α-Fe_2O_3/PVDF (2wt%) 3x1 cm^2 thickness ~110 μm	Rhodamine B (RhB) C= 8 mg/L V= 20 mL	60	US bath W=120 W 40 KHz	90	0.036	This work

1. Ma, W., Yao, B., Zhang, W., He, Y., Yu, Y., & Niu, J. (2021). Fabrication of PVDF-based piezocatalytic active membrane with enhanced oxytetracycline degradation efficiency through embedding few-layer E-MoS2 nanosheets. *Chemical Engineering Journal*, *415*, 129000.
2. Singh, G., Sharma, M., & Vaish, R. (2021). Flexible Ag@ LiNbO3/PVDF composite film for piezocatalytic dye/pharmaceutical degradation and bacterial disinfection. *ACS Applied Materials & Interfaces*, *13*(19), 22914-22925.
3. Liao, X., Chen, X., Tang, Y., Zhu, M., Xie, H., Xin, Y., ... & Fan, X. (2022). Enhanced Piezocatalytic Reactive Oxygen Species Production Activity and Recyclability of the Dual Piezoelectric Cu3B2O6/PVDF Composite Membrane. *ACS Applied Materials & Interfaces*, *15*(1), 1286-1295.
4. Bagchi, B., Hoque, N. A., Janowicz, N., Das, S., & Tiwari, M. K. (2020). Re-usable self-poled piezoelectric/piezocatalytic films with exceptional energy harvesting and water remediation capability. *Nano Energy*, *78*, 105339.
5. Veeralingam, S., & Badhulika, S. (2023). Rapid Degradation of Organic Dyes via Ultrasound Triggered Piezo-Catalysis Using PVDF/ZnSnO3/MoS2 Nanocomposite. *ACS Applied Nano Materials*.
6. Qian, W., Zhao, K., Zhang, D., Bowen, C. R., Wang, Y., & Yang, Y. (2019). Piezoelectric material-polymer composite porous foam for efficient dye degradation via the piezo-catalytic effect. *ACS applied materials & interfaces*, *11*(31), 27862-27869.
7. Liu, C., Xu, H., Huo, B., Wang, J., Wang, Z., Chen, X., ... & Wang, Y. (2023). Research progress of PVDF based piezoelectric polymer composites in water pollution remediation. *Journal of Water Process Engineering*, *55*, 104181.
8. Porwal, C., Verma, S., Chauhan, V. S., & Vaish, R. (2023). Bismuth zinc borate-Polyacrylonitrile nanofibers for photo-piezocatalysis. *Journal of Industrial and Engineering Chemistry*, *124*, 358-367.