Electronic Supplementary Material (ESI) for Nanoscale.

Piezoelectrically Enhanced Photocatalysis of $K_xNa_{1-x}NbO_3$ (KNN) Microstructures for Efficient Water Purification

Runjiang Guo[†a], Mengqian Liu[†a], Yurui Xing[a], Tanglong Bai[a], Chenglong Zhao[a], Haolin Huang[a], and Hongti Zhang*[ab]

[a]School of Physical Science and Technology, ShanghaiTech University, Shanghai, 201210, P.R. China;

[b]Shanghai Key Laboratory of High-resolution Electron Microscopy, ShanghaiTech University, Shanghai, 201210, P. R. China

* Correspondence: zhanght3@shanghaitech.edu.cn

† These authors contributed equally to this work.

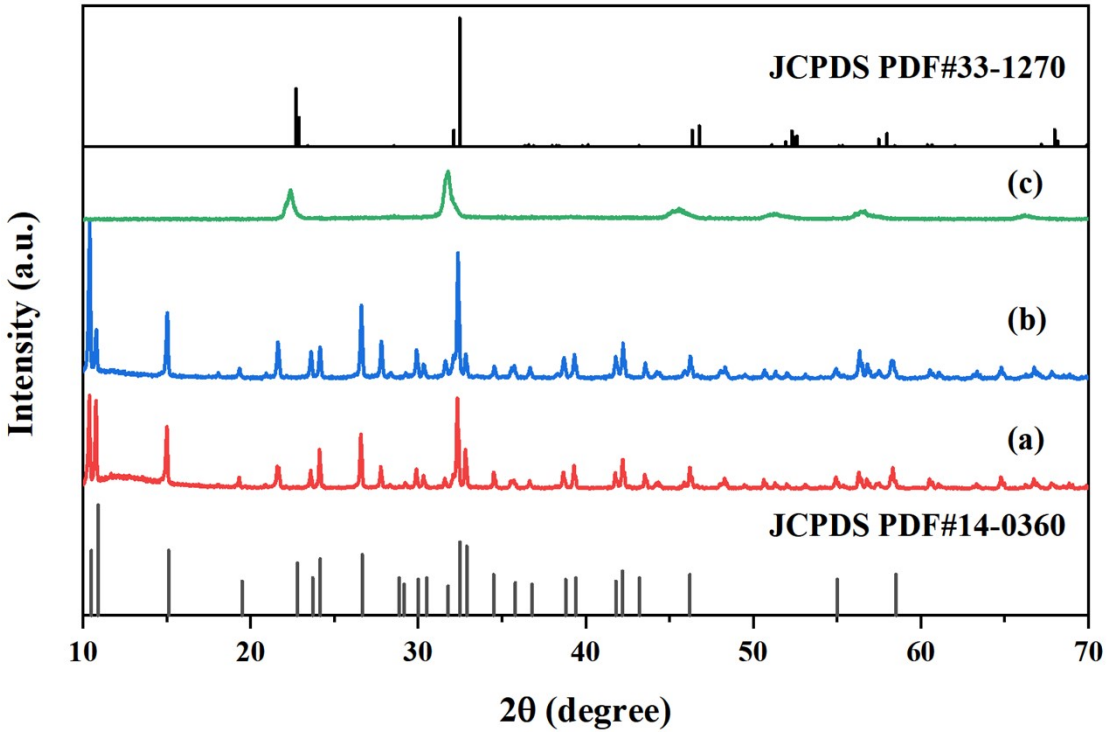

Fig.S1 XRD patterns of KNN powders synthesized under different temperatures: (a) 160 ℃, (b) 180 ℃, (c) 200 ℃.

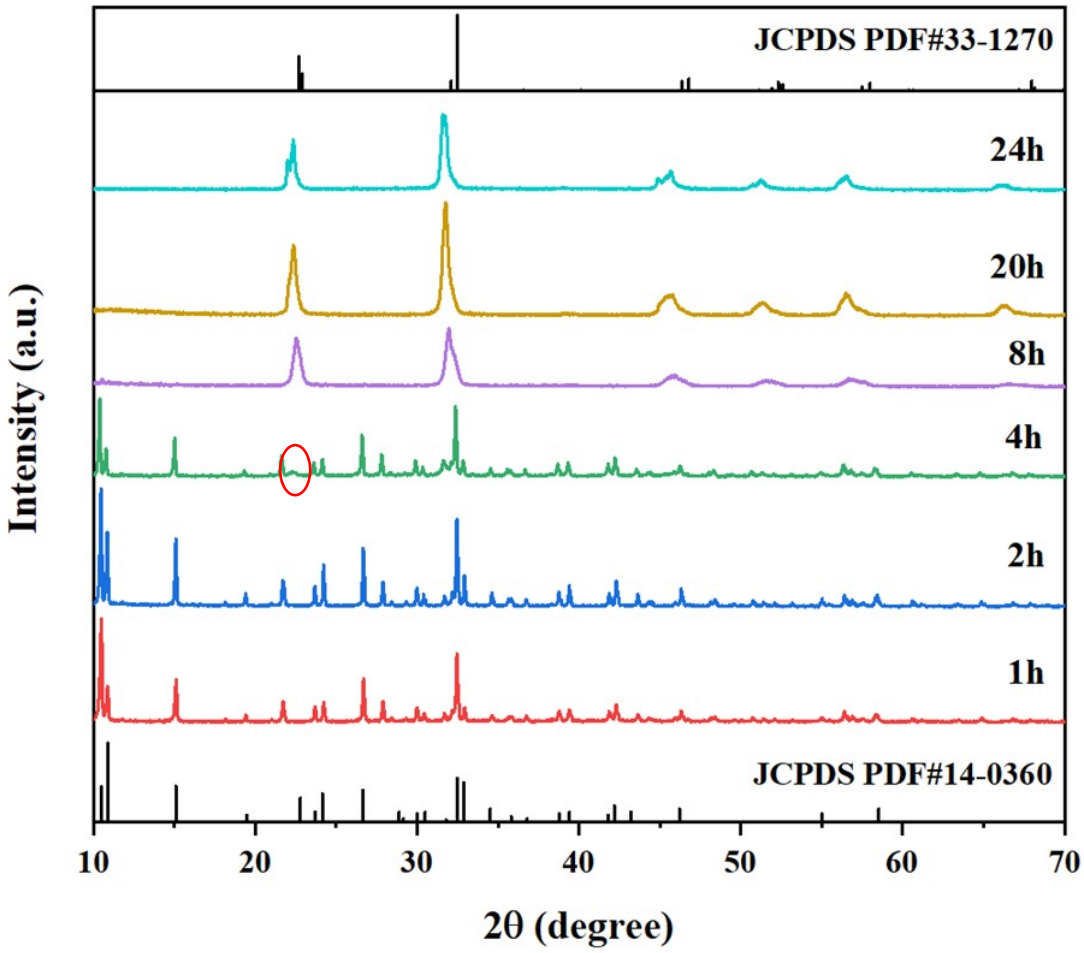

Fig.S2 The XRD patterns of KNN-6 powders synthesized under different reaction time.

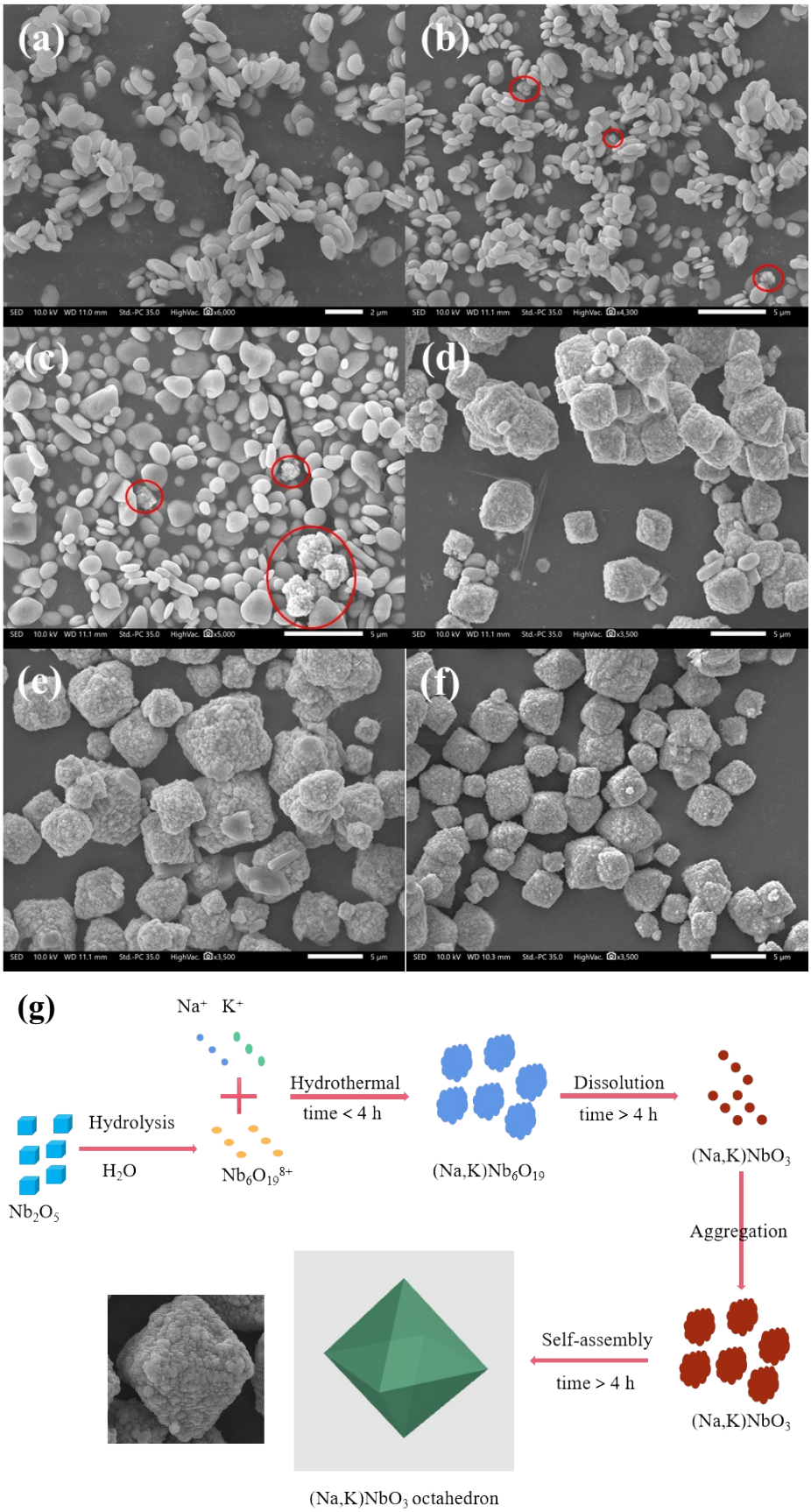

Fig.S3 The SEM images of KNN powders synthesized under different time (a) 1 h, (b) 2 h, (c) 4 h, (d) 8 h, (e) 20h, (f) 24 h; (g) schematic illustration of the KNN-6 formation mechanism.

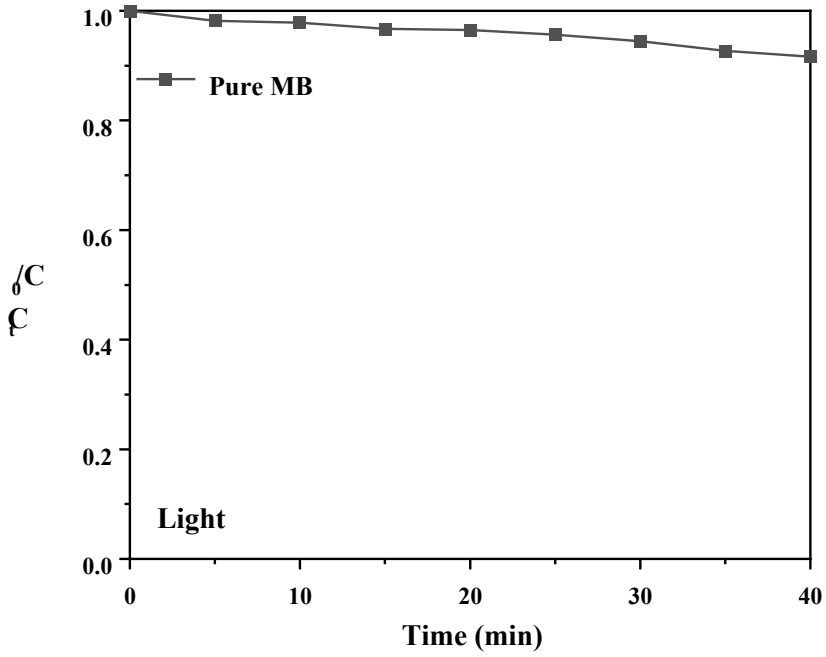

Fig.S4 The degradation of MB under light irradiation without adding any catalyst.

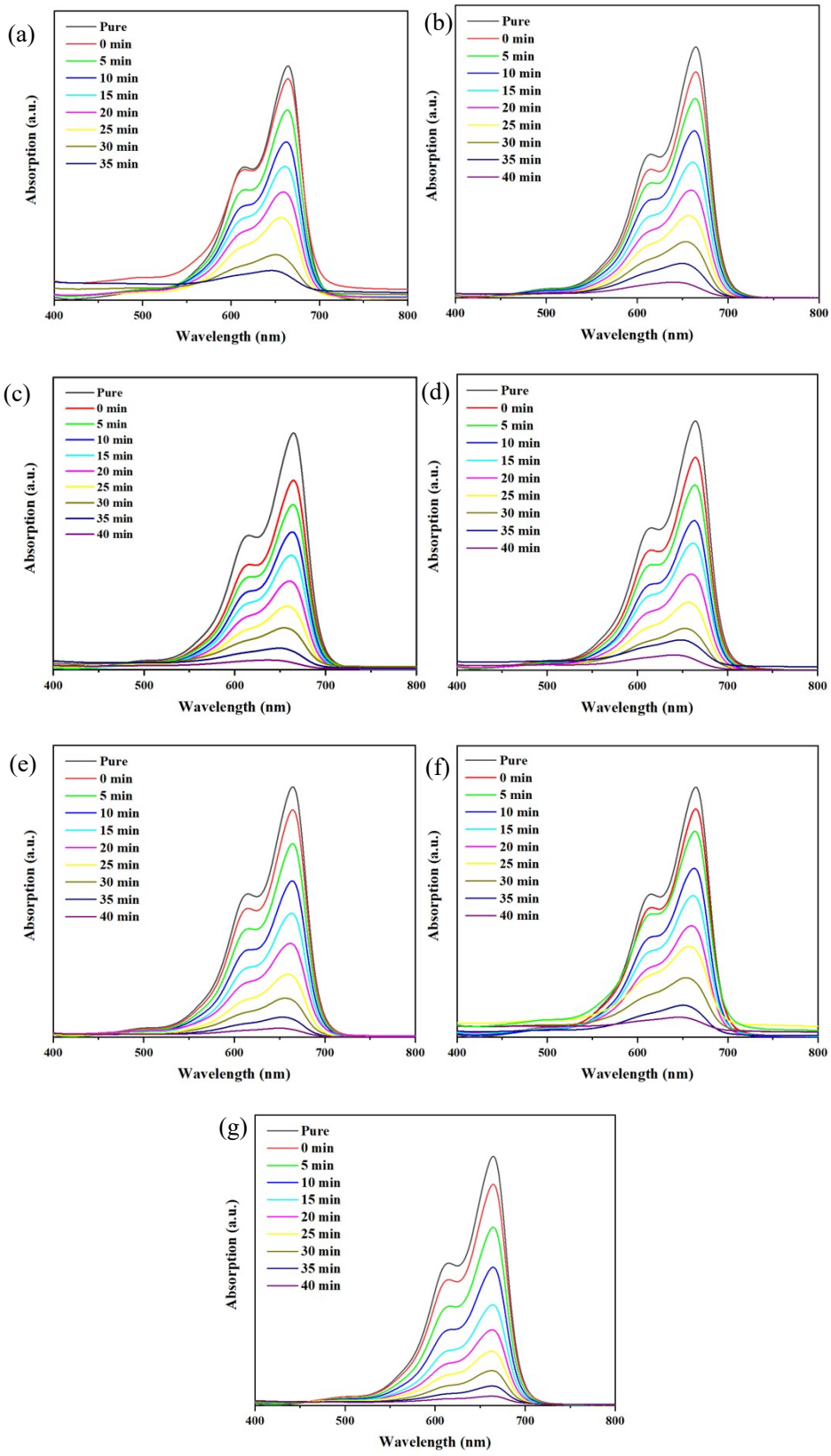

Fig.S5 The UV-vis absorption curves of MB solutions degraded by different KNN samples under condition of light irradiation together with ultrasonic vibration. (a) KNN-0, (b) KNN-5, (c) KNN-6, (d) KNN-7, (e) KNN-8, (f) KNN-9 and (g) KNN-10.

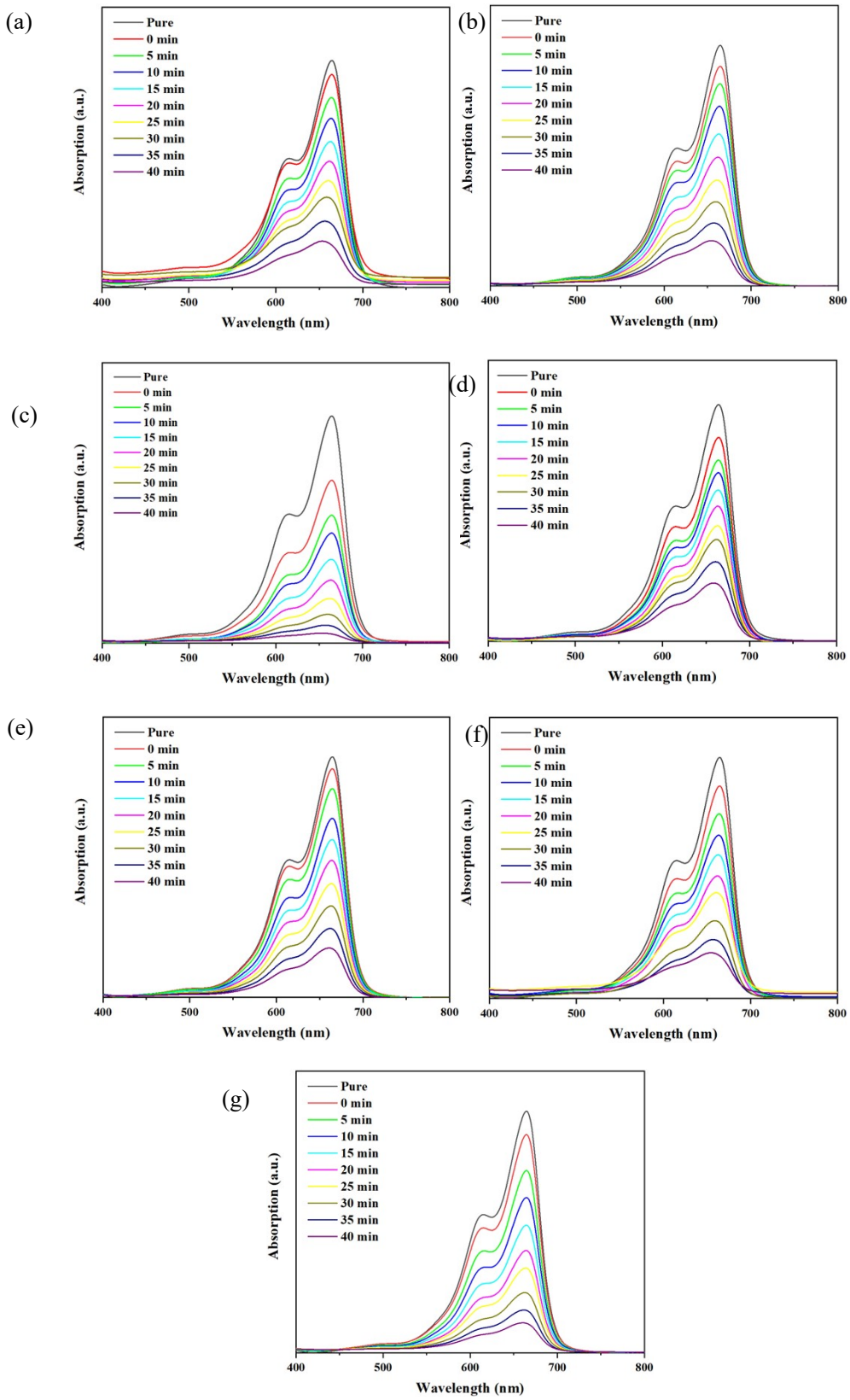

Fig.S6 The UV-vis absorption curves of MB solutions degraded by different KNN samples under condition of light irradiation. (a) KNN-0, (b) KNN-5, (c) KNN-6, (d) KNN-7, (e) KNN-8, (f) KNN-9 and (g) KNN-10.

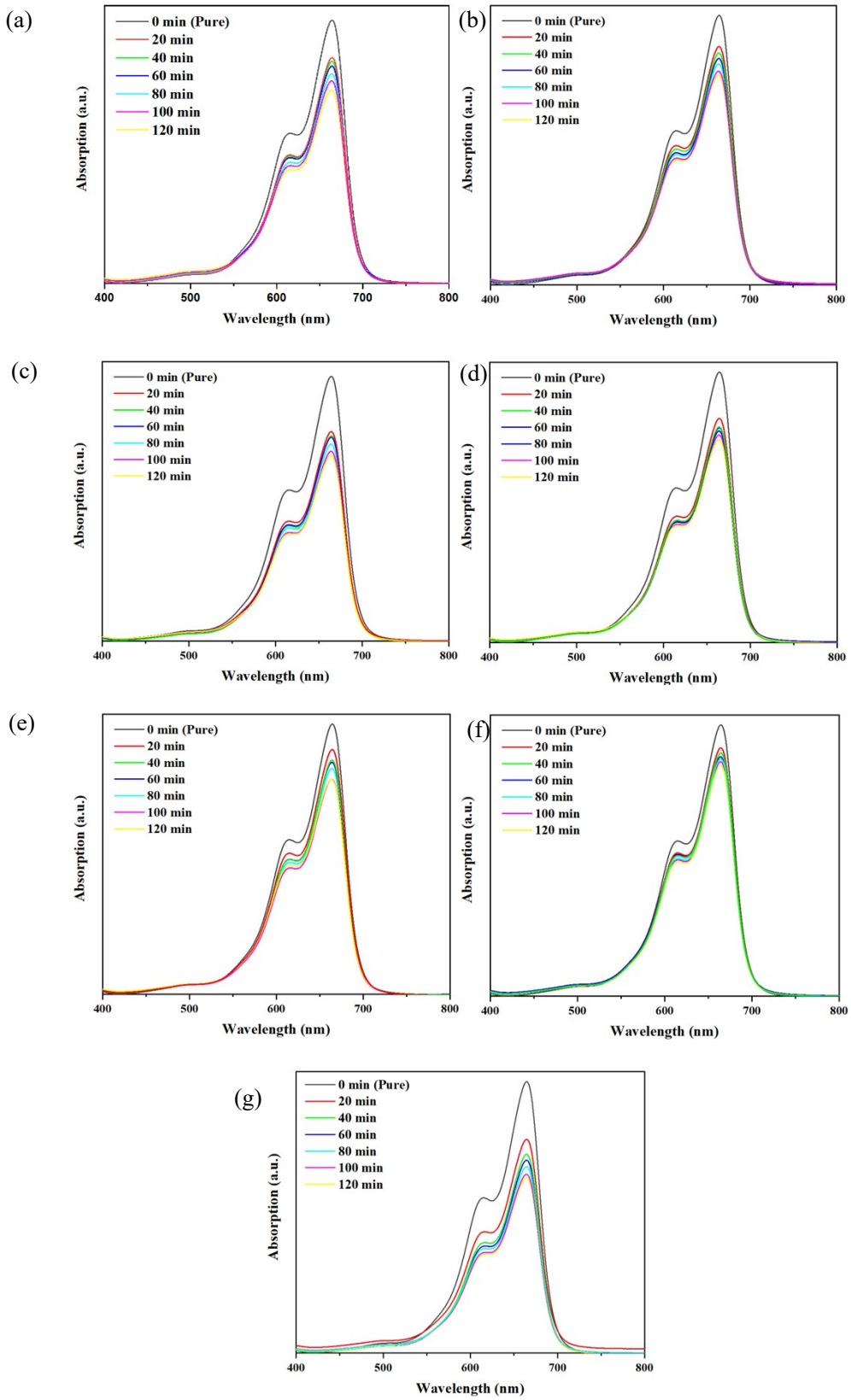

Fig.S7 The UV-vis absorption curves of MB solutions degraded by different KNN samples under condition of ultrasonic vibration. (a) KNN-0, (b) KNN-5, (c) KNN-6, (d) KNN-7, (e) KNN-8, (f) KNN-9 and (g) KNN-10.

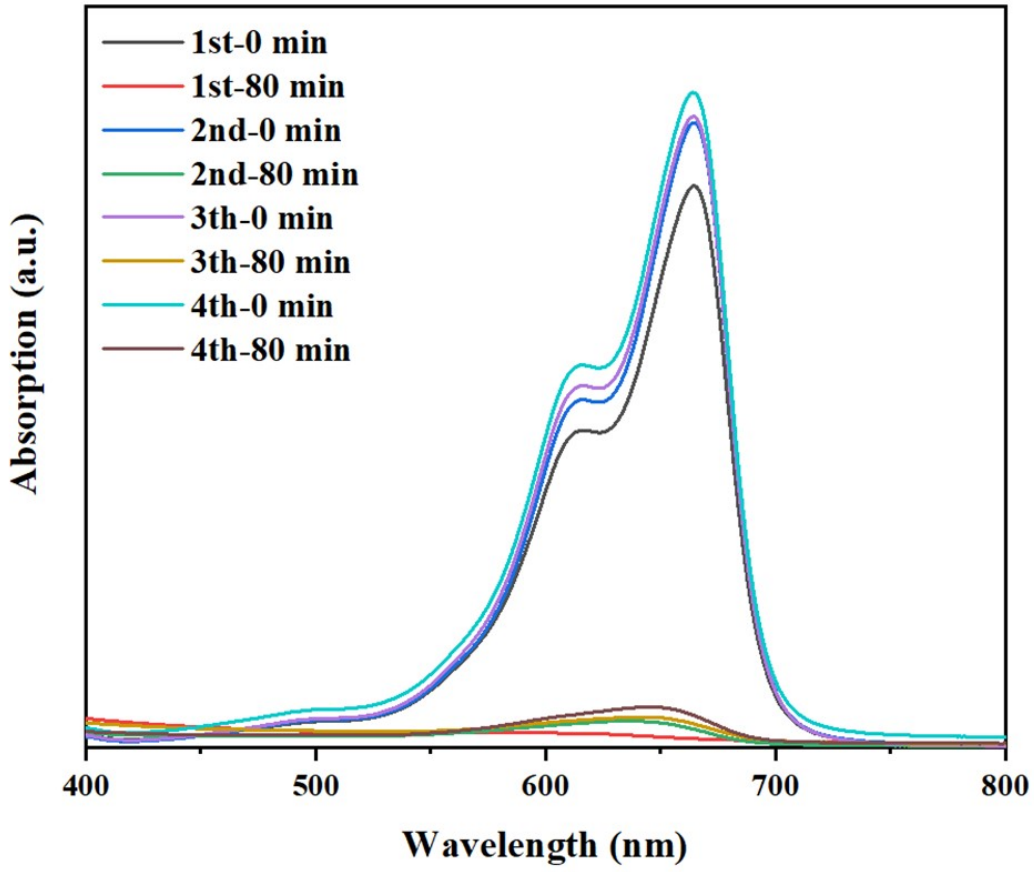

Fig.S8 The UV-vis absorption curves of MB solutions under four cycles of stability tests of the KNN-6 powder.

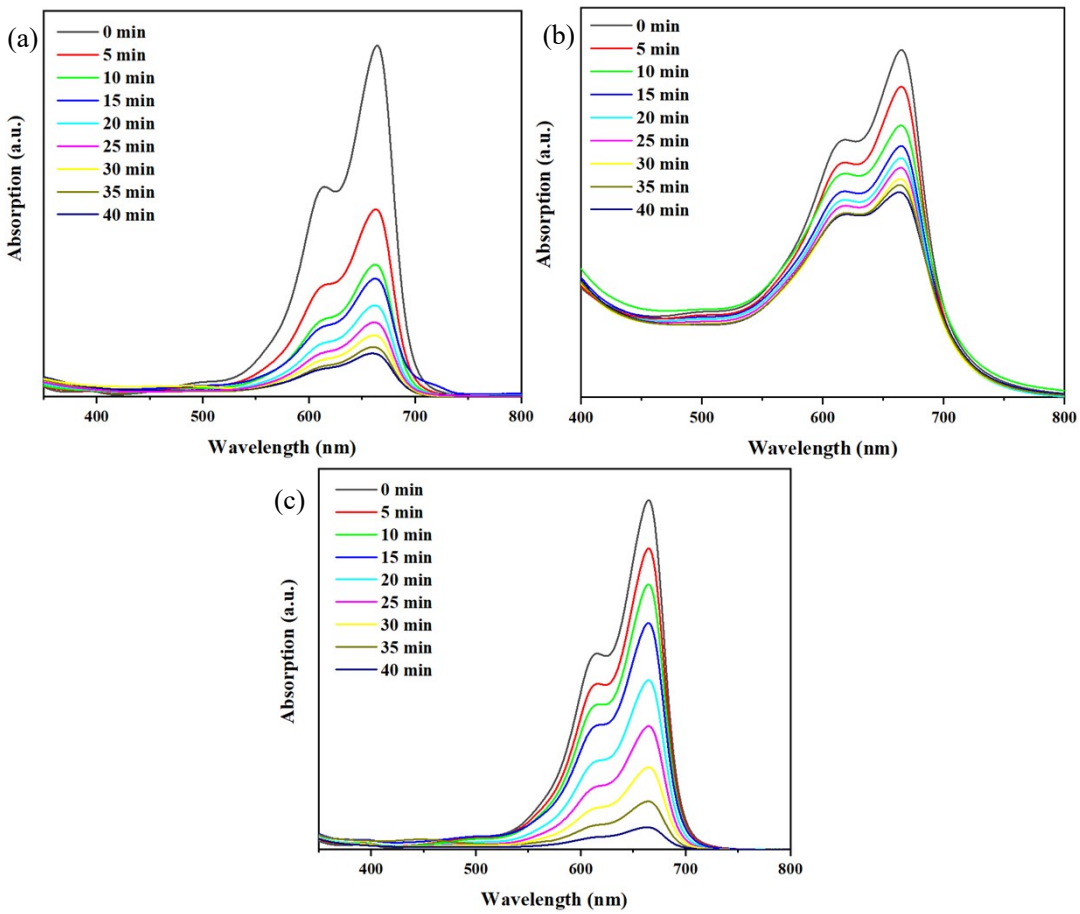

Fig.S9 The degradation efficiency of MB under different scavenger (a) EDTA-2Na. (b) BQ, (c) TBA.

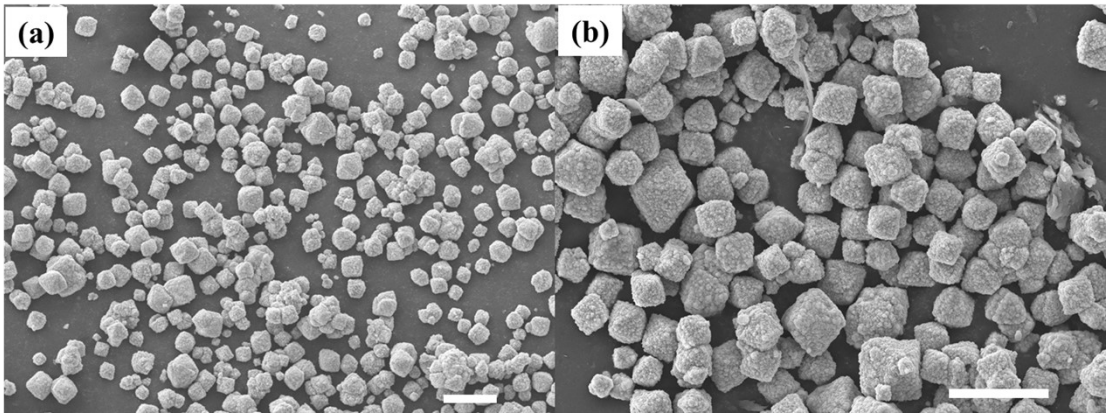

Fig.S10 SEM images of as-synthesized KNN-6 with low magnifications to show their overall octahedron morphologies. (scale bar: 10 μm)

Tab.S1 The MB degradation efficiency in previous reports.

Photocatalysts	**Degradation Efficiency**	**Reaction conditions**	**Ref.**
Polymer/TiO_2 Nanofiber	180min 67%	Sun Light	S1
$NaNbO_3$	180min 73%	Sun Light + Ultrasonic Vibrations	S2
CNTs/TiO_2/AgNPs/Surfactant	120min 99%	Visible Light	S3
ZnO–Yb_2O_3–Pr_2O_3	60min 99.8%	Sun Light	S4
ZnO NPs-PWAC	60min 99%	Sun Light	S5
Ag-$NaNbO_3$	180min 82%	SunLight+Ultrasonic Vibrations	S6
$(Bi_{1/2}Na_{1/2})TiO_3$	150min 54.2%	Ultrasonic Vibrations	S7
BiVO4-ZIF 8	130min 80%	Visible Light	S8
$K_{0.4}Na_{0.6}NbO_3$	40min 98%	Sun Light+Ultrasonic Vibrations	This work

Tab.S2 The catalytic degradation efficiency of other niobate materials reported in works.

Photocatalysts	**Degradated Dye**	**Degradation Efficiency**	**Reaction conditions**	**Ref.**
$NaNbO_3$	RhB	120 min 80%	Sunlight	S9
$NaNbO_3$	MB	180 min 80%	Sun Light + Ultrasonic Vibrations	S2
Ag-doped $NaNbO_3$	MB	180 min 90%	Sun Light + Ultrasonic Vibrations	S6
$NaNbO_3$	RhB	80 min 90%	Sun Light + Ultrasonic Vibrations+heating/cooling	S10
$KNbO_3$	RhB	180 min 96%	Sunlight	S11
N-doped $KNbO_3$	RhB	18h 64%	Visible Light	S12
$KNbO_3$	RhB	120 min 90%	Sun Light + Ultrasonic Vibrations	S13
$K_{0.5}Na_{0.5}NbO_3$	BB41	90 min 90%	Sunlight	S14
$K_{0.5}Na_{0.5}NbO_3$	RhB	100 min 90%	Sun Light + Ultrasonic Vibrations	S15
$K_{0.4}Na_{0.6}NbO_3$	MB	40min 98%	Sun Light+Ultrasonic Vibrations	This work

Reference

[S1] A. Abdal-hay, A.S. Hamdy Makhlouf, K.A. Khalil, Novel, Facile, Single-Step Technique of Polymer/TiO_2 Nanofiber Composites Membrane for Photodegradation of Methylene Blue, *ACS Applied Materials & Interfaces*, 7 (2015) 13329-13341.

[S2] S. Singh, N. Khare, Coupling of piezoelectric, semiconducting and photoexcitation properties in $NaNbO_3$ nanostructures for controlling electrical transport: Realizing an efficient piezo-photoanode and piezo-photocatalyst, *Nano Energy*, 38 (2017) 335-341.

[S3] E.M.S. Azzam, N.A. Fathy, S.M. El-Khouly, R.M. Sami, Enhancement the photocatalytic degradation of methylene blue dye using fabricated CNTs/TiO_2/AgNPs/Surfactant nanocomposites, *Journal of Water Process Engineering*, 28 (2019) 311-321.

[S4] T. Munawar, S. Yasmeen, M. Hasan, K. Mahmood, A. Hussain, A. Ali, M.I. Arshad, F. Iqbal, Novel tri-phase heterostructured ZnO–Yb_2O_3–Pr_2O_3 nanocomposite; structural, optical, photocatalytic and antibacterial studies, *Ceramics International*, 46 (2020) 11101-11114.

[S5] M. Kamaraj, N.R. Srinivasan, G. Assefa, A.T. Adugna, M. Kebede, Facile development of sunlit ZnO nanoparticles-activated carbon hybrid from pernicious weed as an operative nano-adsorbent for removal of methylene blue and chromium from aqueous solution: Extended application in tannery industrial wastewater*, Environmental Technology & Innovation*, 17 (2020) 100540.

[S6] D. Kumar, S. Sharma, N. Khare, Piezo-phototronic and plasmonic effect coupled Ag-$NaNbO_3$ nanocomposite for enhanced photocatalytic and photoelectrochemical water splitting activity, *Renewable Energy*, 163 (2021) 1569-1579.

[S7] D. Liu, Y. Song, Z. Xin, G. Liu, C. Jin, F. Shan, High-piezocatalytic performance of eco-friendly $(Bi_{1/2}Na_{1/2})TiO_3$-based nanofibers by electrospinning, *Nano Energy*, 65 (2019) 104024.

[S8] Y.-h. Si, Y.-y. Li, Y. Xia, S.-k. Shang, X.-b. Xiong, X.-r. Zeng, J. Zhou, Fabrication of Novel ZIF-8@$BiVO_4$ Composite with Enhanced Photocatalytic Performance, *Crystals*, 8 (2018).

[S9] S. Wang, Z. Wu, J. Chen, J. Ma, J. Ying, S. Cui, S. Yu, Y. Hu, J. Zhao, Y. Jia, Lead-free sodium niobate nanowires with strong piezo-catalysis for dye wastewater degradation, *Ceramics International*, 45 (2019) 11703-11708.

[S10] H. You, X. Ma, Z. Wu, L. Fei, X. Chen, J. Yang, Y. Liu, Y. Jia, H. Li, F. Wang, H. Huang, Piezoelectrically/pyroelectrically-driven vibration/cold-hot energy harvesting for mechano-/pyro-bi-catalytic dye decomposition of NaNbO3 nanofibers, *Nano Energy*, 52 (2018) 351-359.

[S11] T.B. Wermuth, S. Arcaro, J. Venturini, T.M. Hubert Ribeiro, A. de Assis Lawisch Rodriguez, E.L. Machado, T. Franco de Oliveira, S.E. Franco de Oliveira, M.N. Baibich, C.P. Bergmann, Microwave-synthesized KNbO3 perovskites: photocatalytic pathway on the degradation of rhodamine B, *Ceramics International*, 45 (2019) 24137-24145.

[S12] R. Wang, Y. Zhu, Y. Qiu, C.-F. Leung, J. He, G. Liu, T.-C. Lau, Synthesis of nitrogen-doped KNbO3 nanocubes with high photocatalytic activity for water splitting and degradation of organic pollutants under visible light, *Chemical Engineering Journal*, 226 (2013) 123-130.

[S13] D. Yu, Z. Liu, J. Zhang, S. Li, Z. Zhao, L. Zhu, W. Liu, Y. Lin, H. Liu, Z. Zhang, Enhanced catalytic performance by multi-field coupling in KNbO3 nanostructures: Piezo-photocatalytic and ferro-photoelectrochemical effects, *Nano Energy*, 58 (2019) 695-705.

[S14] F. Praxedes, M. Nobre, P. Poon, J. Matos, S. Lanfredi, Nanostructured $K_xNa_{1-x}NbO_3$ hollow spheres as potential materials for the photocatalytic treatment of polluted water, *Appl. Catal. B-Environ*, 298 (2021) 120502.
[S15] A. Zhang, Z. Liu, X. Geng, W. Song, J. Lu, B. Xie, S. Ke, L. Sun, Ultrasonic vibration driven piezocatalytic activity of lead-free $K_{0.5}Na_{0.5}NbO_3$ materials, *Ceram. Int.* 45 (2019) 22486-22492.