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Synthesis and Photocatalytic Activity of the Oxysulfide Perovskite $KTaO_{3-x}S_x$

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INTRODUCTION & AIM

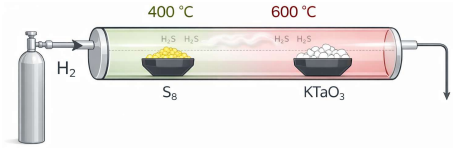
Oxide perovskite $KTaO_3$ is a promising photocatalytic material due to its high chemical and structural stability, however, its use in the visible range is limited by a wide band gap (Eg ≈ 3.6 eV) due to the formation of a valence band by O 2p-states and a conduction band by d states of Ta^{5+}.

One of the ways to modify the electronic structure is the partial anionic substitution of oxygen with sulfur to form oxysulfide phases $KTaO_{3-x}S_x$, which leads to an increase in the valence band due to S 3p-states and contributes to a narrowing of the band gap and an expansion of absorption into the visible region of the spectrum.

METHOD

PREPARATION OF $KTaO_{3-x}S_x$

$KTaO_{3-x}S_x$ powders were obtained in two steps: $KTaO_3$ was first synthesised by a solid-state reaction between K_2CO_3 and Ta_2O_5 at 800 °C for 8 h, and then $KTaO_3$ was treated at 600 °C in an H_2S atmosphere.



CHARACTERIZATION OF $KTaO_{3-x}S_x$

Composition were studied using scanning electron microscopy (SEM) on a JSM-7600F (JEOL, Japan) equipped with an EDS detector (Oxford Instruments, UK).

Crystal structure changes were monitored using XRD on a DRON-3 X-ray diffractometer (NPO Burevestnik, Russia) using CoKα radiation at 40 kV.

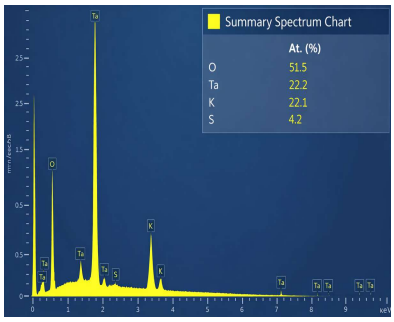
PHOTOCATALYTIC TESTS OF $KTaO_{3-x}S_x$

The photocatalytic activity of $KTaO_{3-x}S_x$ particles was assessed by the degree of RhB decomposition under sunlight exposure, and the contribution of various catalytically active particles to the process was assessed using scavenger experiments (IPA, BQ, DMSO, EDTA.

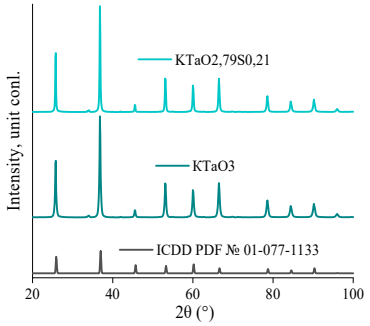
RESULTS & DISCUSSION

✓ Oxysulfide perovskites $KTaO_{3-x}S_x$ with sulfur contents of 1.8, 4.2 and 7.4 at.% were obtained.

SEM images and total EDX spectra of $KTaO_{2.79}S_{0.21}$ particles

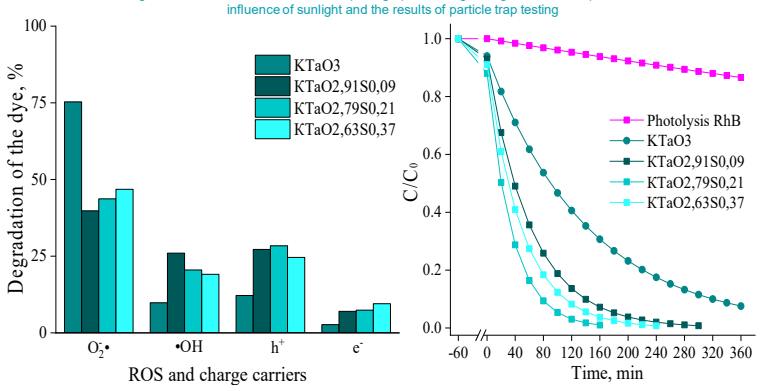


X-ray diffraction patterns of $KTaO_{2.79}S_{0.21}$ and $KTaO_3$ particles



The samples are single-phase, and the $KTaO_3$ structure is preserved over the entire sulfur-doping range studied.

Photodegradation of 50 mL of RhB solutions (10 mg/L) containing 40 mg of $KTaO_{3-x}S_x$ particles under the influence of sunlight and the results of particle trap testing



The $KTaO_{2.79}S_{0.21}$ sample (4.2 at.% S) exhibits the highest photocatalytic activity under solar-light irradiation: in RhB degradation its activity is 2.25 times higher than that of pristine $KTaO_3$, with superoxide anion $O_2^{\bullet-}$ being the main active species.

CONCLUSION

It is shown that sulfurization of $KTaO_3$ in H_2S vapour enables controlled formation of the oxysulfide perovskite $KTaO_{3-x}S_x$. Sulfur doping increases the photocatalytic activity by more than a factor of two: the composition containing 4.2 at.% S exhibits an activity of 12.5 $mg \cdot g^{-1} \cdot h^{-1}$ in RhB degradation under solar-light irradiation.

ACKNOWLEDGEMENTS

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