Investigation of the behaviour and photoactivity of $SrTiO_3$ nanomaterials in acidic and neutral soil extracts

Badam ARIYA[1,*], SOLYMOS Karolina[1,4], Dr. GYULAVÁRI Tamás[1], Dr. PAP Zsolt[1,2,3], Dr. BABCSÁNYI Izabella[1,4], Dr. FARSANG Andrea[4]

(1) Department of Applied and Environmental Chemistry, University of Szeged, Rerrich tér 1, Szeged, Hungary, HU-6720
(2) Laboratory for Advanced Materials and Applied Technologies, Institute for Research, Development and Innovation in Applied Natural Sciences, Fantanele 30, Cluj-Napoca, Romania. RO-400294
(3) Centre of Nanostructured Materials and Bio-Nano Interfaces, Institute for Interdisciplinary Research on Bio-Nano-Sciences, Treboniu Laurian 42, Cluj-Napoca, Romania. RO-400271
(4) Department of Geoinformatics, Physical and Environmental Geography, University of Szeged, Szeged, Hungary, HU-6722
E-mail: *ariya.badam@chem.u-szeged.hu

Introduction

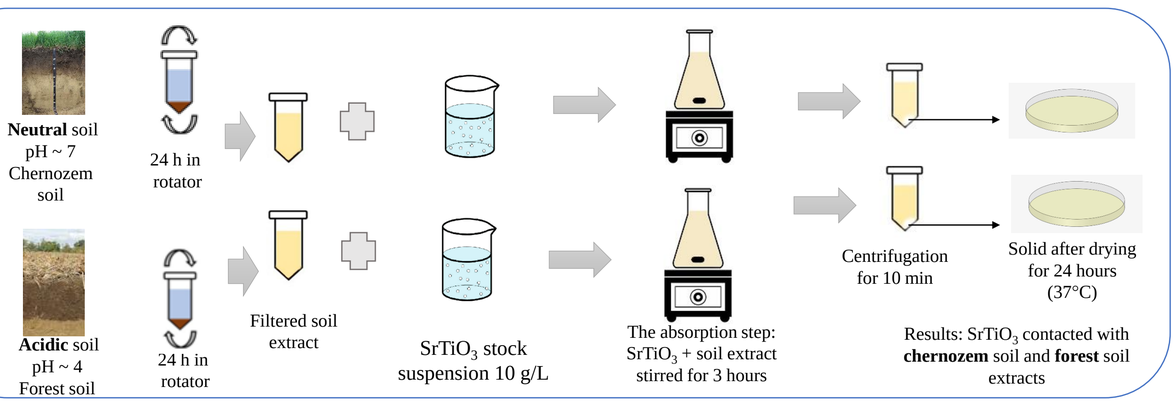
Strontium titanate ($SrTiO_3$) has been used for various applications, such as energy storage, fuel cells, and hydrogen production by photocatalysis. Hence, studying the behaviour and interactions of such NPs soil solutions is a prerequisite for avoiding ecological risks related to such new materials. This study was focused on conducting laboratory experiments in soil containing $SrTiO_3$ NPs, such as commercial and synthesised $SrTiO_3$.

Objectives:

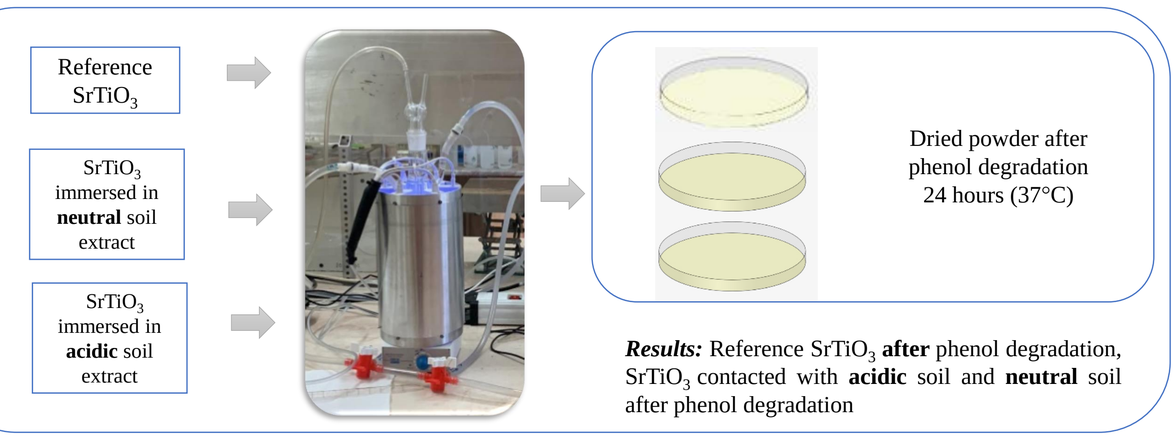
- investigating the **changes in the photocatalytic activity** of $SrTiO_3$ NPs following their interactions with the **different soil solutions** (in neutral phaeozem, which is chernozem soil with pH~7 and acidic regosol, which is forest soil with pH~4);
- studying the **degradation of the dissolved natural organic material** in the soil solution by the addition of $SrTiO_3$ catalysts.

Experimental

Adsorption experiment schematic representation



Photocatalytic activity experimental setup

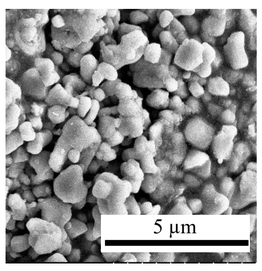


Characterization and photocatalytic activity

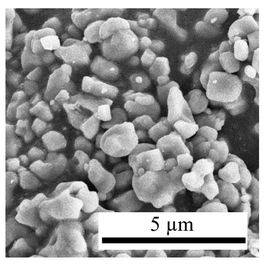
$SrTiO_3$ samples were characterized by X-ray diffractometry (XRD), scanning electron microscopy (SEM), and diffuse reflectance spectroscopy (DRS), while the photocatalytic activity was assessed by phenol degradation under UV-A light (the concentration was followed via high performance liquid chromatography (HPLC)).

Morphology – SEM

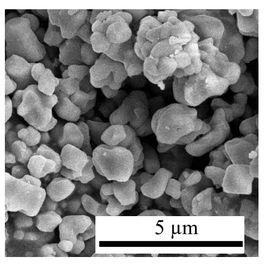
$SrTiO_3$ Reference



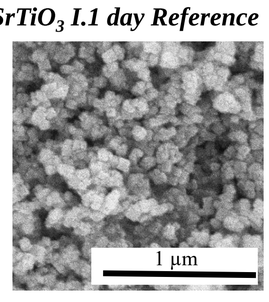
$SrTiO_3$ Chernozem soil



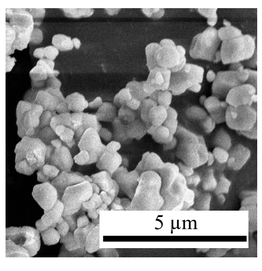
$SrTiO_3$ Forest soil



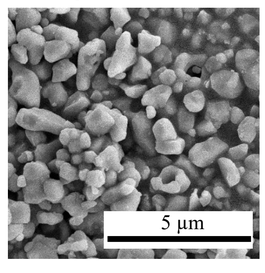
$SrTiO_3$ I.1 day Reference



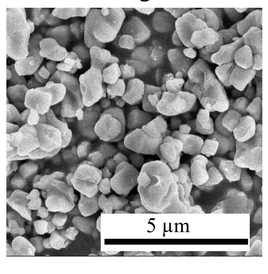
$SrTiO_3$ after Phenol degradation



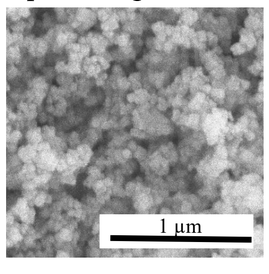
$SrTiO_3$ Chernozem after Phenol



$SrTiO_3$ Forest soil after Phenol degradation



$SrTiO_3$ I.1 day after phenol degradation

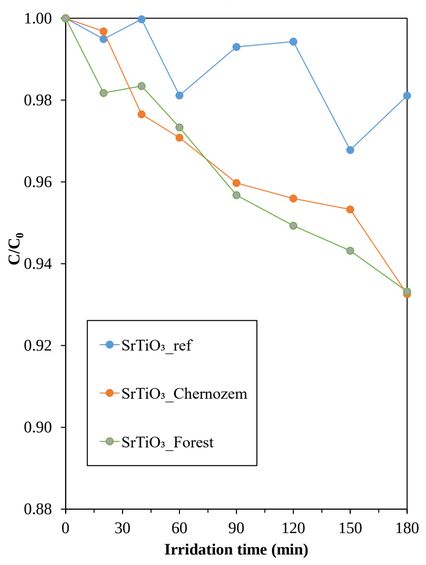


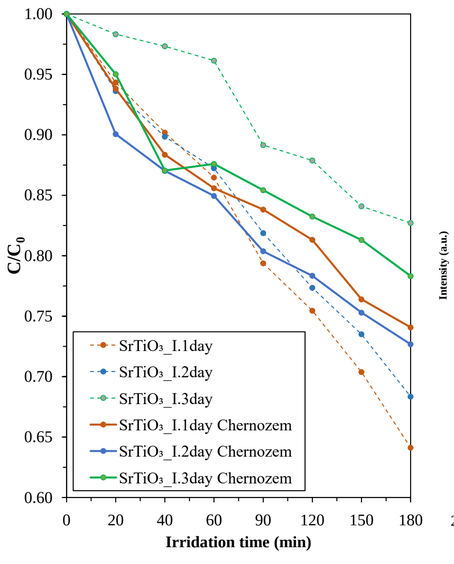
The SEM measurements of the reference $SrTiO_3$ showed that the particles underwent a slight aggregation after phenol degradation. Forest soil extract disaggregated the particles into smaller chunks, but there were no significant changes in the morphology.

The SEM micrograph of reference synthesized $SrTiO_3$ showed that there were no significant changes in morphology after degradation.

Characterization and photocatalytic activity

Photocatalytic activity

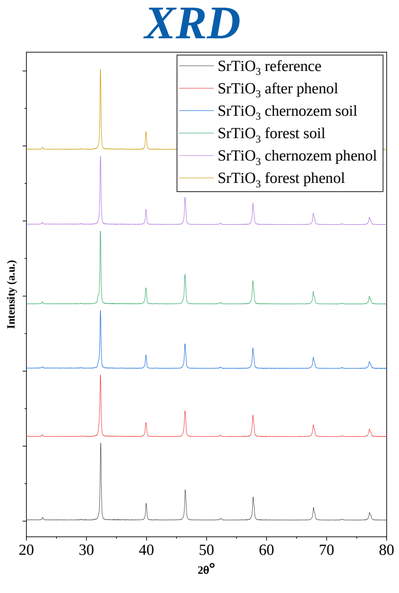




During the photocatalytic activity there was differences between reference $SrTiO_3$ and $SrTiO_3$ which absorbed acidic and neutral soil extracts.

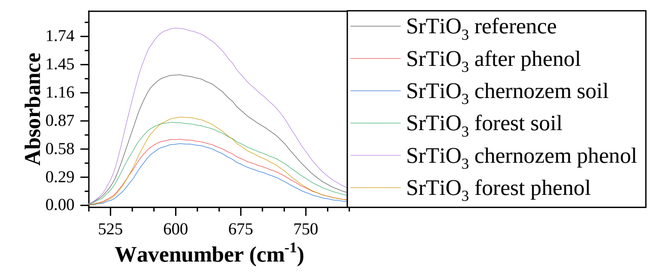
During the photocatalytic activity of synthesized $SrTiO_3$, neutral soil extract increased the 3 day's sample activity and decreased 1&2 day's sample activities.

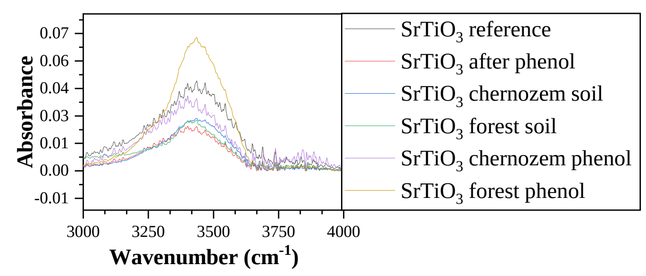
XRD



The XRD measurements showed that were no significant differences between the samples.

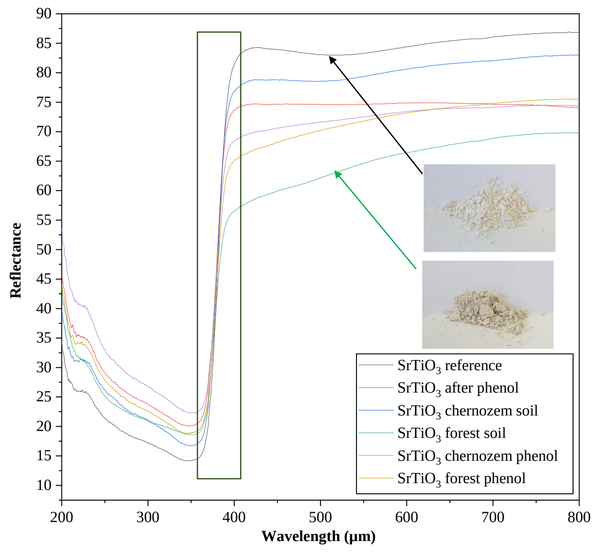
IR measurements





1. There were no significant differences in the M-O region of the spectrum.
2. Major changes were observed in the water band at 3500 cm^{-1} after the interaction with the soil extracts

DRS measurement



In DRS measurements there were no changes in the band gap energy when all the samples were compared. However, the light absorption in the visible showed major differences. $SrTiO_3$ which adsorbed soil extracts becomes yellowish or greyish visually after the process (see photo).

Summary

There are following preliminary results. Such as:

- No significant changes were observed in the morphology and crystal structure.
- Infrared spectroscopy measurement showed the changes on H-O-H bond and Oxide bond region in $SrTiO_3$ which absorbed the forest soil extracts. It means this soil enhances the $SrTiO_3$ hydrophilicity.
- Diffuse reflectance spectroscopy (DRS) investigation shows that optical properties of both chernozem and forest soil extract enhanced the absorption of visible light.
- Photocatalytic activity evaluation showed the degradation of phenol, soil extracts decreased the photocatalytic activity of $SrTiO_3$.
- In further research, other types of synthesized $SrTiO_3$ and other types of soil solutions will be obtained above research as well.
- The above preliminary results will be examined in detail and the relationship between the properties of the soil solutions will be considered in detail.

NEMZETI KUTATÁSI, FEJLESZTÉSI ÉS INNOVÁCIÓS HIVATAL

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