

## Introduction

Research is underway in the framework of the project NANOREM, aiming to develop new types of iron nanoparticles for the remediation of the rock environment that are stable in air and do not have to be stored in an inert atmosphere. This greatly simplifies handling of the material during remediation (transport and preparation onsite). The pyrophoric properties of these nanoparticles are suppressed by stabilizing their surface using an inorganic shell, which prevents rapid oxidation (degradation) on contact with air. The aim of presenting methodologies for laboratory tests is to confirm the influence of activation of new type of iron nanoparticles (NANO FER STAR) on their reactive and migration properties. The activation process involves leaving a prepared stock slurry in a concentrated state (usually 20% wt.) for 48 hours and causes disintegration of the inorganic surface shell.

## Methodology

**Migration tests:** details of methodology see Fig. 1. Vertical orientation and washing against the direction of gravity. Concentration of nZVI at the input to the column ca. 1,2 g/L. Concentration of total Fe in time measured in output water. pH and ORP measured continuously. At the end of test measured the concentration of total Fe in whole column. Breakthrough curves of each type of nZVI and distribution curves of the nZVI in the columns evaluated and compared with each other.

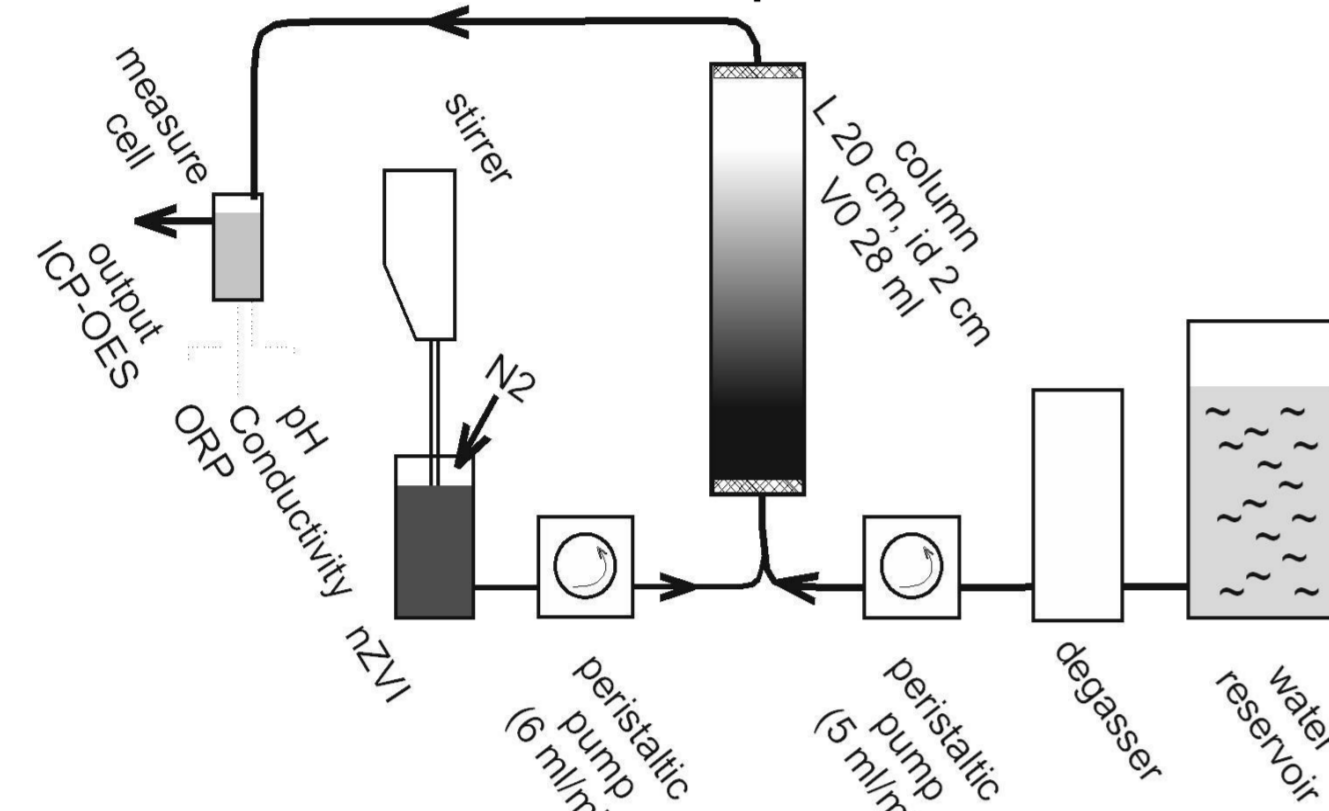


Fig. 1: Block diagram of the column test

**Reactivity tests:** using reagent 100, 250, 500 ml bottles with a Teflon septum. Each sample container used for a single sample and therefore constitutes one time step of the kinetics. The reactor tests - an extension of the batch tests. Using a working stirred reactor with 2.5 litres of contaminated water into which the nZVI dosed. The decrease in the concentration of contamination after the application of the and changes in the pH, ORP monitored (CHC: GC/MS – Varian 3800/Saturn 2200; pH, ORP: WTW 3430i). Concentration and kinetic tests with water from sites.

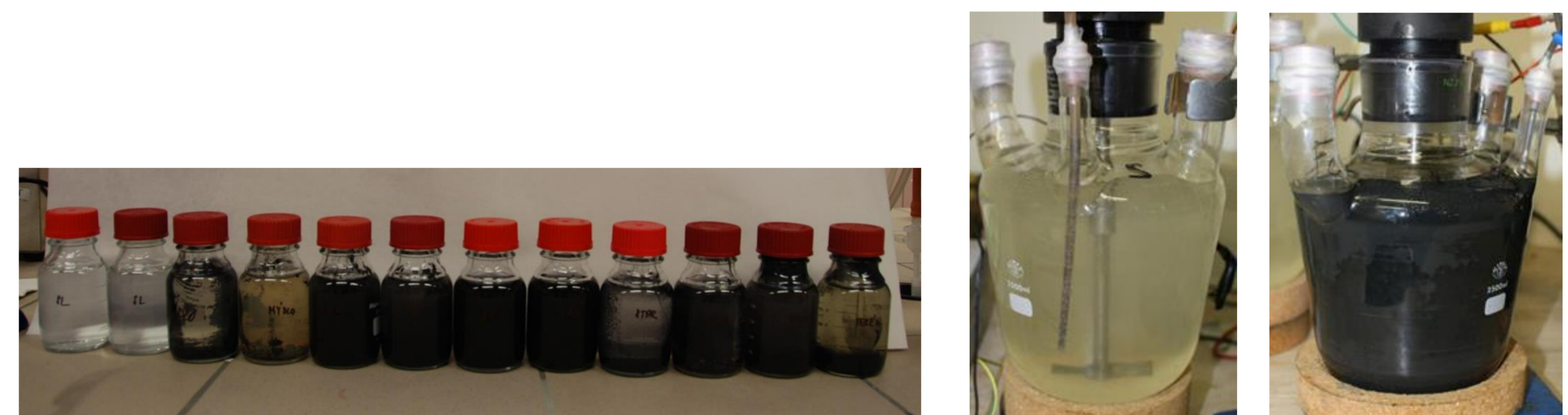


Fig. 2: Left – Reagent bottles for kinetic batch tests; Right – reactors

## Results

### Column tests:

Type of nZVI	NF STAR 197 non-activated	NF STAR 197 activated
Fe <sub>in</sub> (mg/l)	1890 mg/l	1713 mg/l
Total Fe on the output (mg) (%)	47 mg (2%)	72 mg (3%)
Total Fe in the column (mg) (%)	2421 mg (98%)	2592 mg (97%)
Length of sand bed (cm)	21,3	21
Pore volume of the column (ml)	25,2	27,0

Fig. 3: Overall balance of nZVI before and after activation process

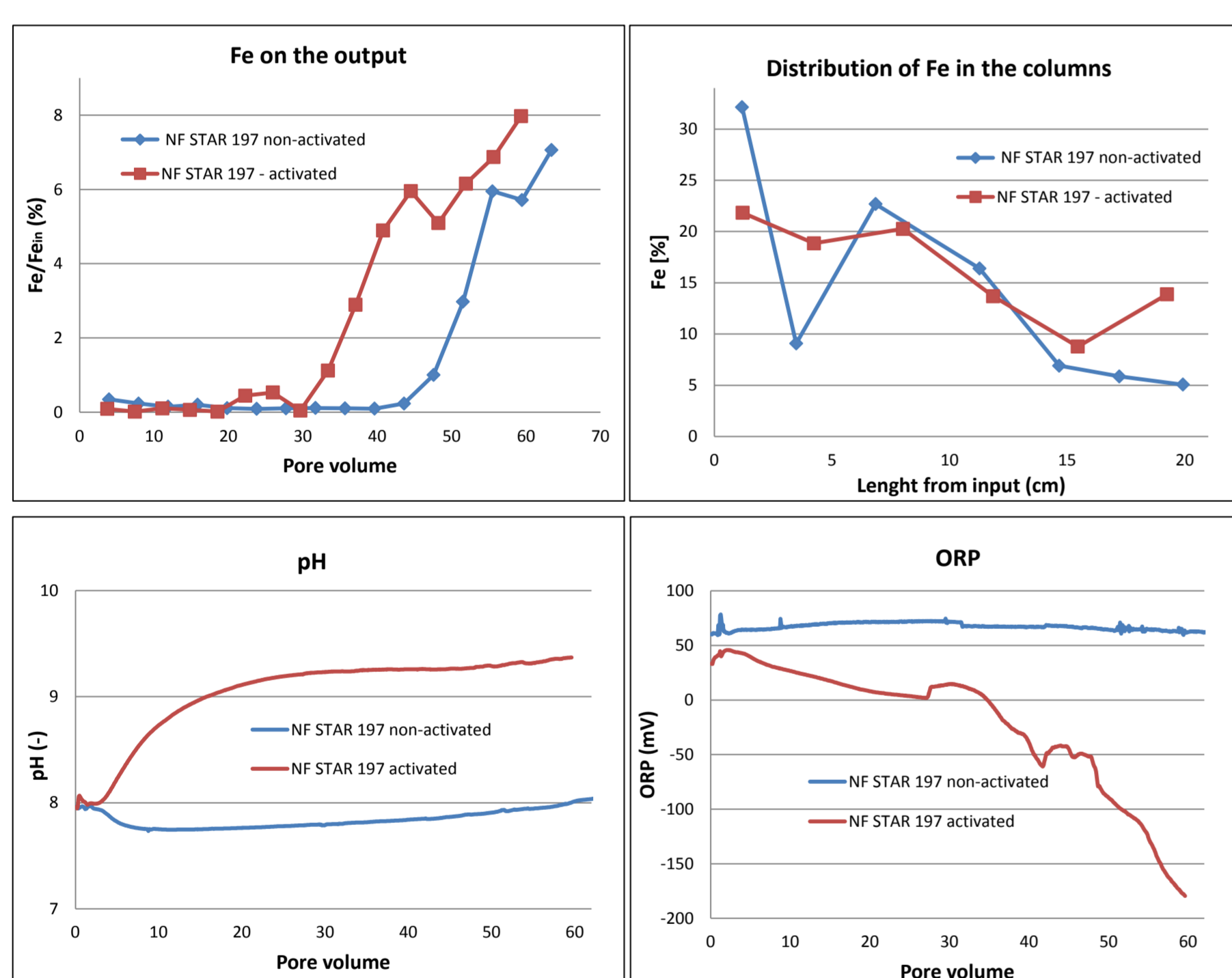


Fig. 4: Comparison of migration properties of non-activated and activated NF STAR and changes in physical-chemical parameters

### Batch tests:

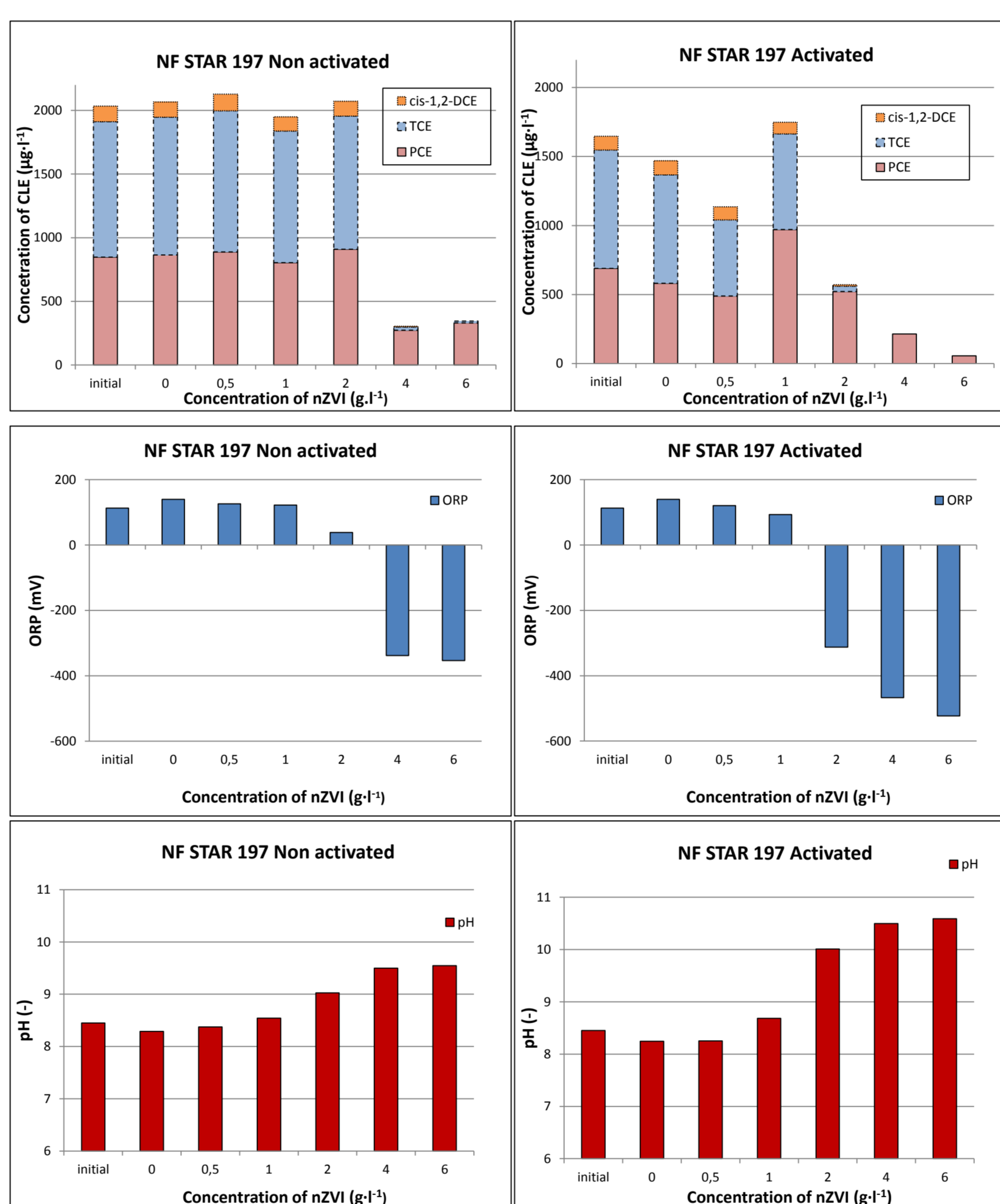


Fig. 5: Reactivity tests with CHC using different concentrations of non-activated and activated NF STAR and changes in phys.-chem. parameters

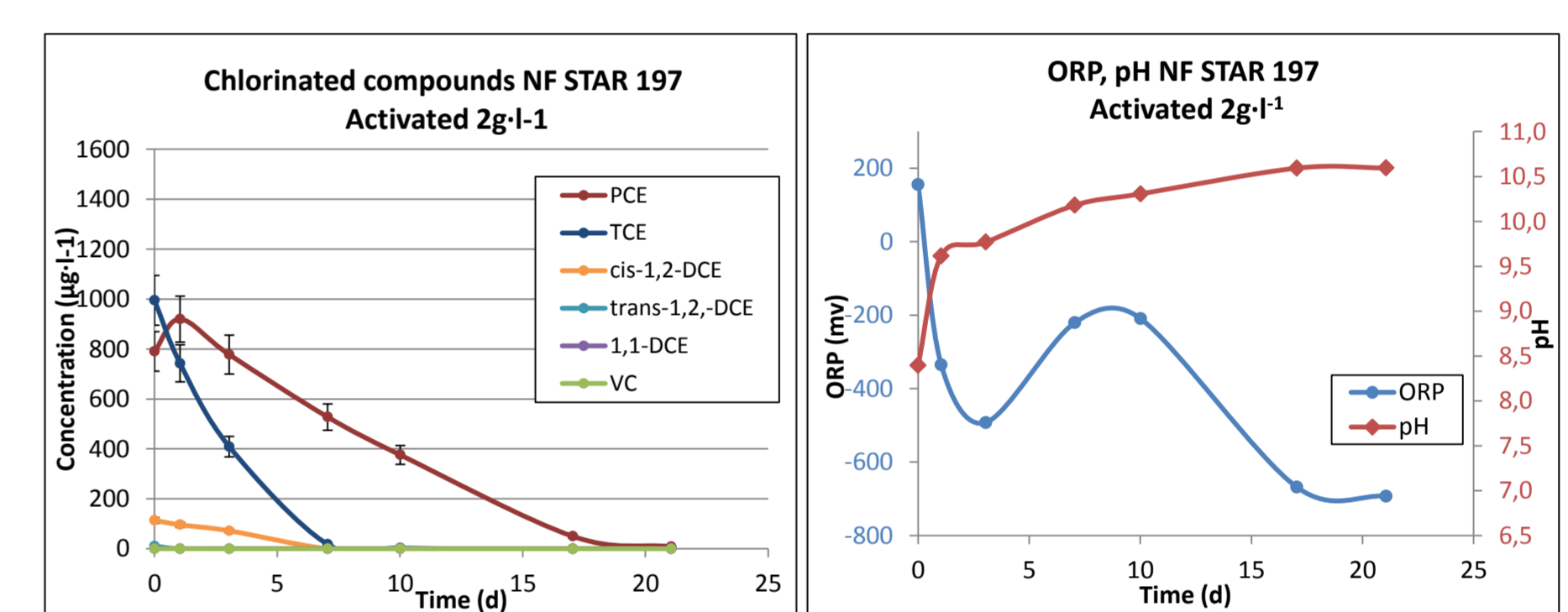


Fig. 6: Kinetic test with CHC using activated NF STAR with concentration 2 g/L and changes in phys.-chem. parameters

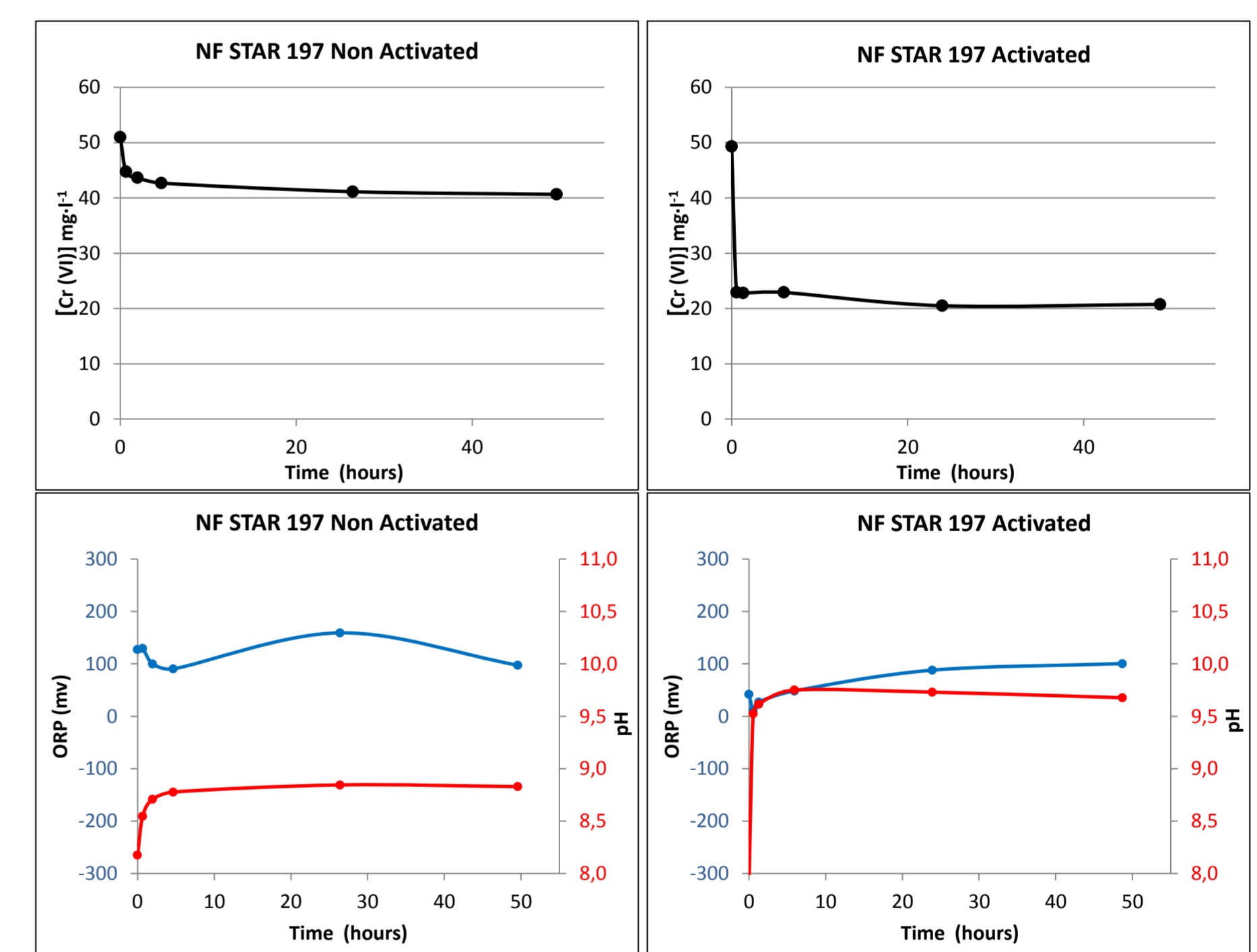


Fig. 7: Reactivity tests of non-activated and activated NF STAR through Cr(VI) to Cr(III) conversion and changes in phys.-chem. parameters

- The results of the performed tests show that the activated NF STAR iron nanoparticles are significantly more reactive and achieve better migration parameters. The disintegration of the inorganic surface shell causes that the particles have more negative Zeta-potential. This fact improve their migration and contribute to better distribution in the rock environment.
- The pilot and field tests confirmed that dilution to low application concentrations and dilution with the groundwater during transport in the rock environment does not lead to the disintegration of the inorganic surface shell (to the activation of the nanoparticles). This causes lower reactivity and increase of the remediation costs.

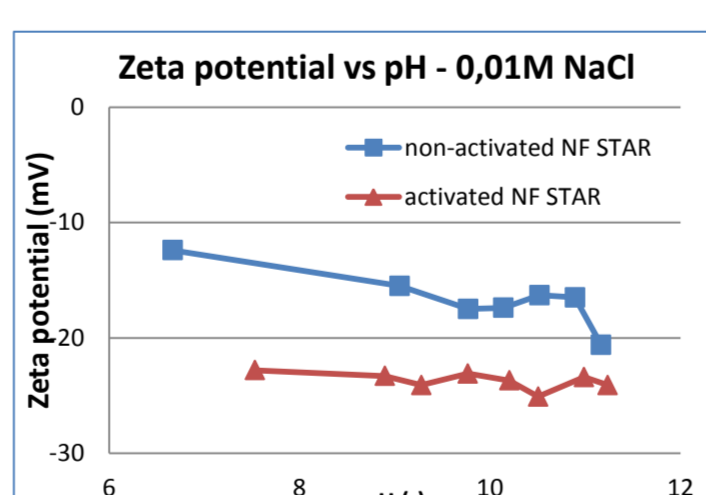


Fig. 8: Changes in Zeta-potential after activation

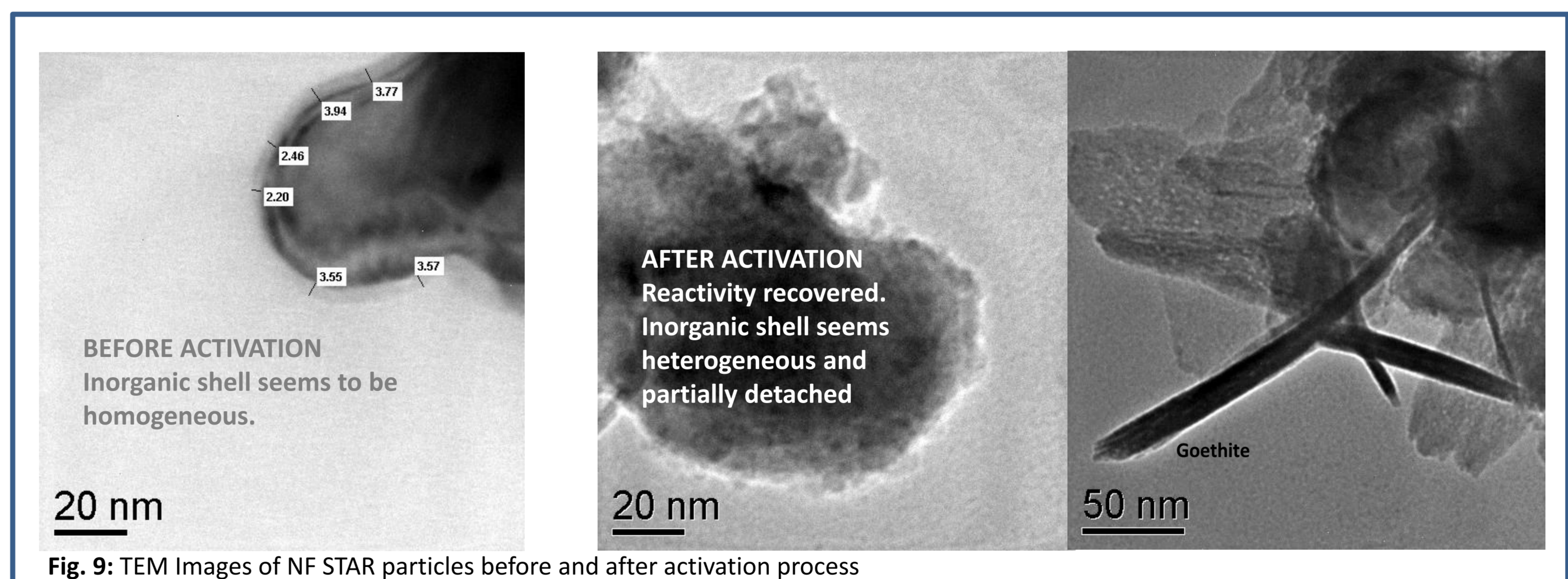


Fig. 9: TEM Images of NF STAR particles before and after activation process

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