Development of innovative functional high-performing clay-based sensing fabrics for environmental parameters detection

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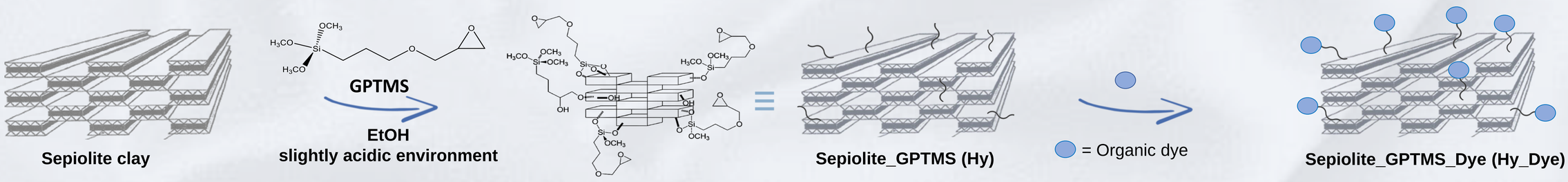
INTRODUCTION

Nowadays, environmental pollution, deriving from anthropological activities, is a serious threat to the well-being of ecosystem and its inhabitants. Real-time and field monitoring methods are essential to assess environmental quality and to identify sources of pollution. Recently, the scientific community is focusing on the development of optical sensors for the detection of environmental parameters and contaminants. In particular, colorimetric sensors show promising potential for the detection of metal ions, anions, organic dyes, drugs, pesticides and other toxic pollutants due to their easy fabrication, high sensitivity and rapid naked-eye detection.

This research study shows the development of a user-friendly adsorbing prototype system, capable of colorimetrically responding to the presence of various environmentally parameters (i.e., pH, heavy metals etc.) in aqueous matrix. In particular, a hybrid material based on sepiolite functionalized with the cross-linker 3-Glycidyloxypropyl)trimethoxysilane (GPTMS) was developed and employed for the immobilization of different organic dyes and applied on cotton fabrics.

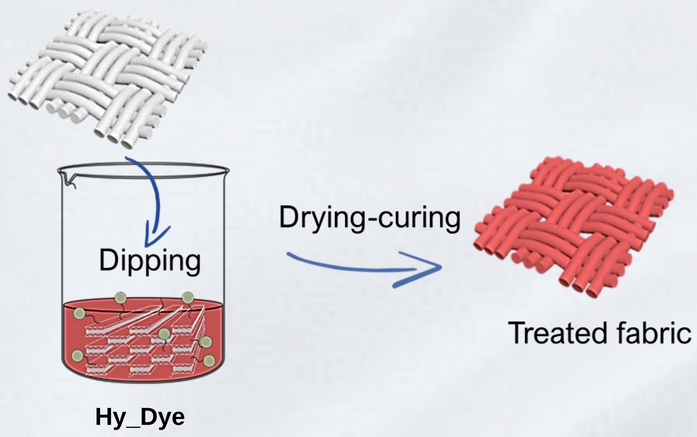
SEPIOLITE FUNCTIONALIZATION BY SOL-GEL METHOD

- The surface of sepiolite has a great ability for grafting reactions with organosilanes due to its high content of silanol groups at the external surface.
- By hydrolysis, the methoxy groups of GPTMS are converted to silanol groups, which react with -OH groups of sepiolite forming Si–O–Si covalent bonds.
- Organic dye nucleophilic addition to the GPTMS through epoxy ring-opening reaction.



TREATMENT OF COTTON FABRICS

Cotton fabrics were cut into small pieces (2 x 1 cm) and were immersed in Hy_Dye solution for 24 h at room temperature. Impregnated fabrics were cured at 110 °C for 1h and washed with ethanol and distilled water for 3 times.



STIMULI RESPONSIVE TEST

The fabric samples functionalized with the different dyes were tested for the colorimetric pH detection.
In particular, three solutions at pH 3,7 and 11 (using HCl or NaOH) were used to visualize colorimetric variations of the fabrics (Figure 1, 2).

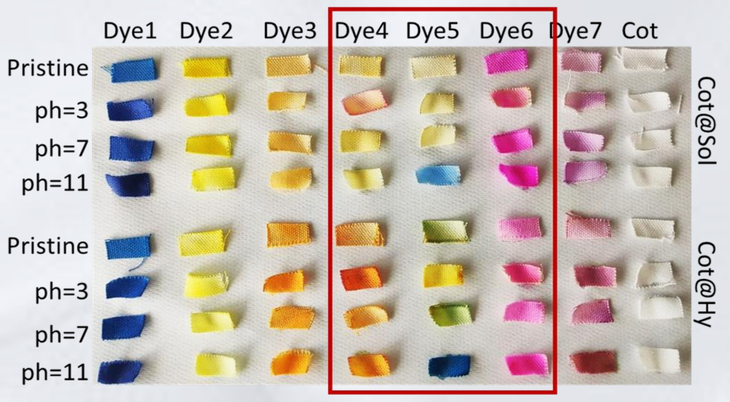


Figure 1. Colorimetric variation of different samples at various pH; red square indicates the samples that had the best response.

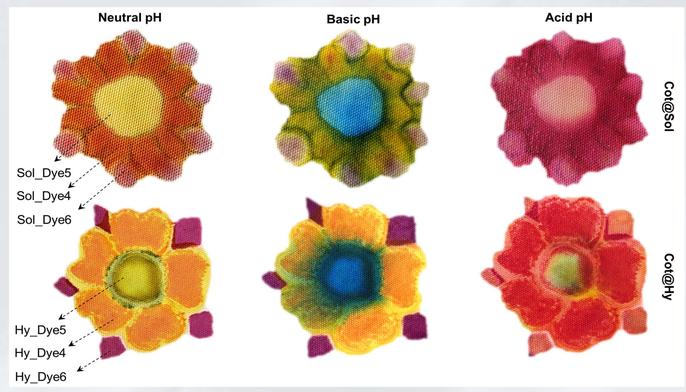


Figure 2. Preliminary tests for validation in relevant laboratory environment.

CHARACTERIZATION

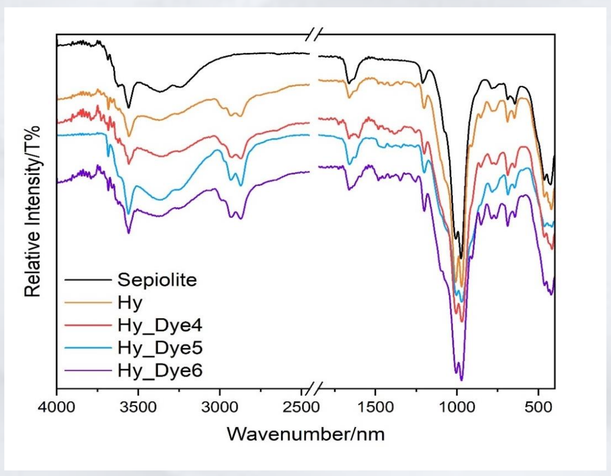


Figure 3. ATR-FT-IR of sepiolite/GPTMS/dye hybrid materials in the powder form.

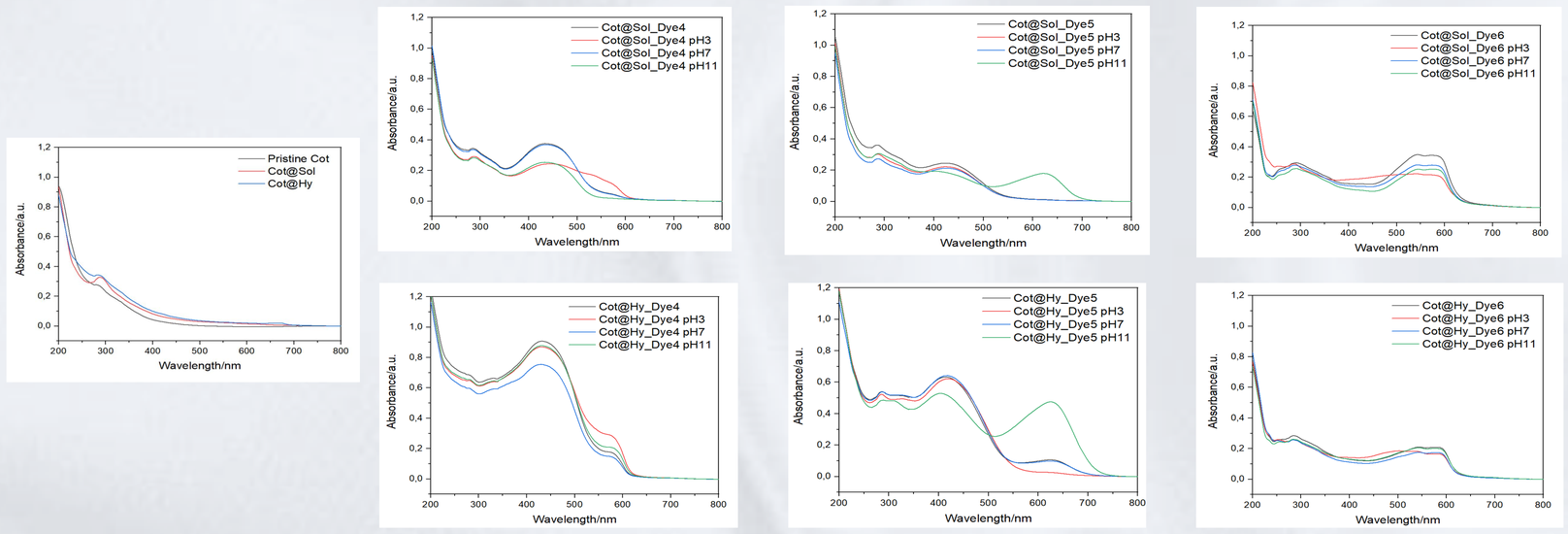


Figure 4. UV-Vis (equipped with the integration sphere accessory) spectra of Cot@Sol and Cot@Hy samples without and with the embedded dyes that showed the best stimuli-responsive features at different pHs.

CONCLUSIONS

- ❖ Innovative functional high-performing sensing fabrics, based on sepiolite clay, were produced through sustainable sol-gel technique.
- ❖ The obtained materials will be further characterized by performing structural-morphological characterizations.
- ❖ In light of the tests carried out, the systems will be further tested to study colorimetric variations in the presence of various heavy metals.

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