
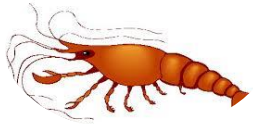


Natural coatings on titanium surfaces to improve their biological response

S. Ferraris[1], E. Verné[1], G. Örlygsson[2], P. Tambasco[3], F. Perraro Sehn[3], Chuen-How Ng[4], H. Janusson[4], G. Banche[5], V. Allizond[5], C. M. Bertea[5], L. Rimondini[6], A. Cochis[6], V. Guarino[7], A. Varesano[8], C. Vineis[8], G. Gautier di Confiengo[9], S. Spriano[1]

[1] Politecnico di Torino –ITALY; [2] Innovation Center Iceland – ICELAND; [3] University of Sao Paulo – BRAZIL; [4] Genis hf. – ICELAND; [5] Università di Torino – Italy; [6] Università del Piemonte Orientale – Italy; [7] CNR-IPCB, Naples – Italy; [8] CNR-STIIMA Biella – Italy, [9] CNR-IMAMOTER - Italy

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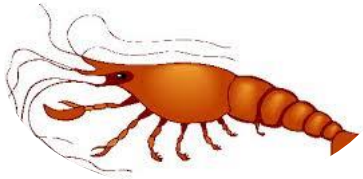
From abundant byproduct/local natural resources to high added value products for biomedical applications

KERATIN



CHITOSAN

PEPPERMINT ESSENTIAL OIL

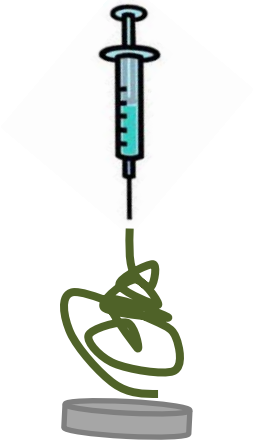
Sustainable Use of Resources and promotion of local economies

&

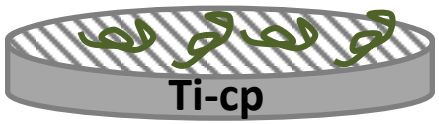
Innovative high added value biomedical products with low side effects and environmental impact

Keratin from discarded wool

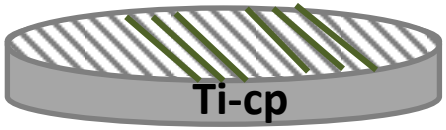
Elettrospinning from formic acid solutions

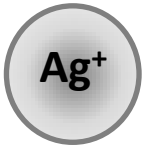


Stationary collector: **randomly riented fibers**



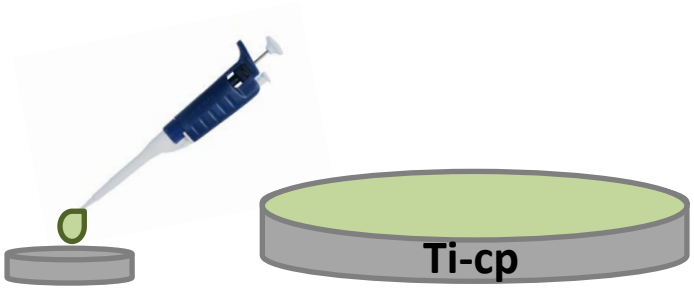
Rotating collector: **aligned fibers**





Silver doping from $AgNO_3$ solution for antibacterial activity

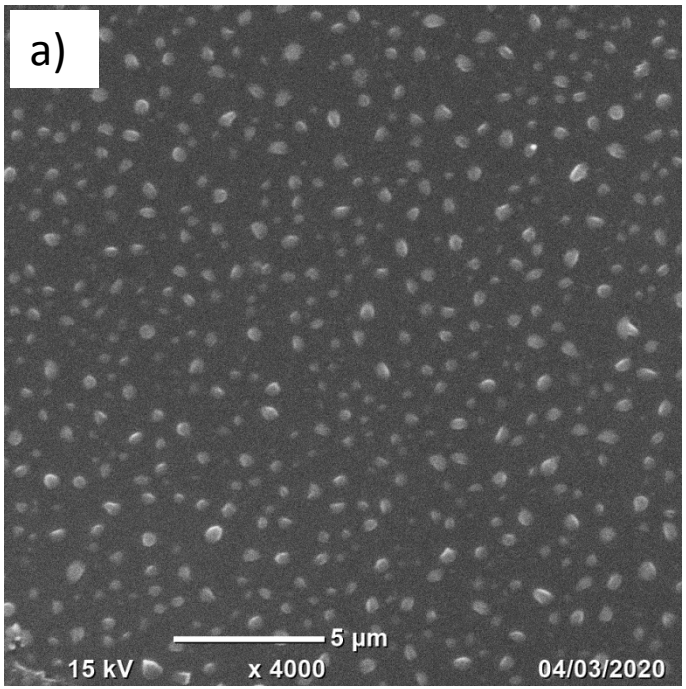
Deposition from aqueous solutions



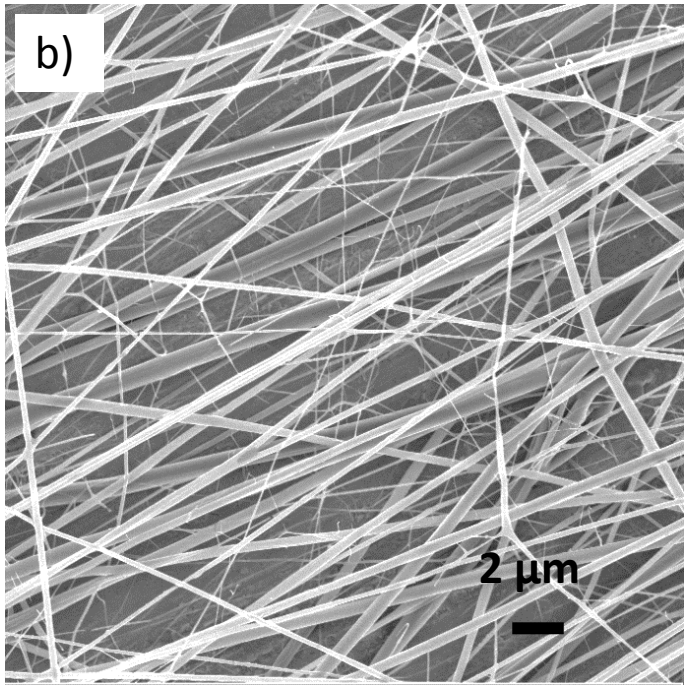
Continuous coatings

S. Ferraris et al. Mat Sci Eng C 76 (2017) 1–12
S Ferraris et al. Mater Lett 229 (2018) 1–4
A Cochis et al. J. Mater. Chem. B, 2017, 5, 8366

Keratin from discarded wool

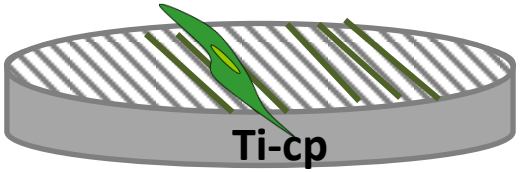


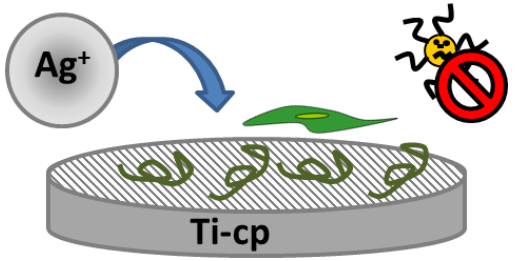
Keratin continuous coating



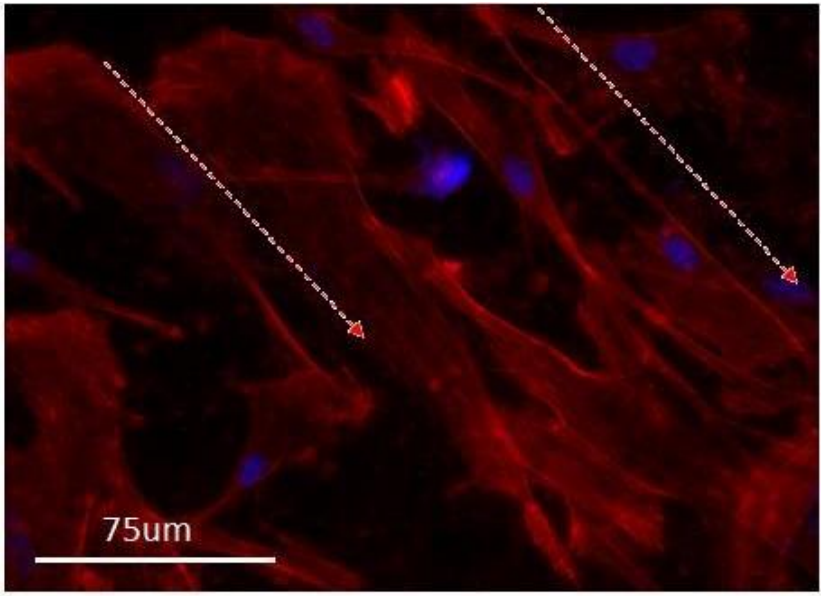
Keratin sub-micrometric fibers

Keratin from discarded wool

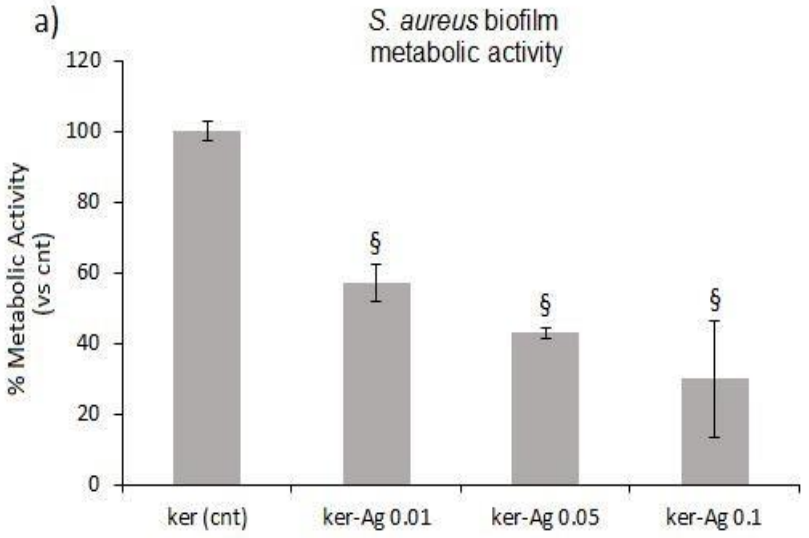




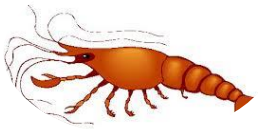
Fibroblast alignment in the fibers direction



Reduction of S. aureus adhesion on Ag-doped fibers

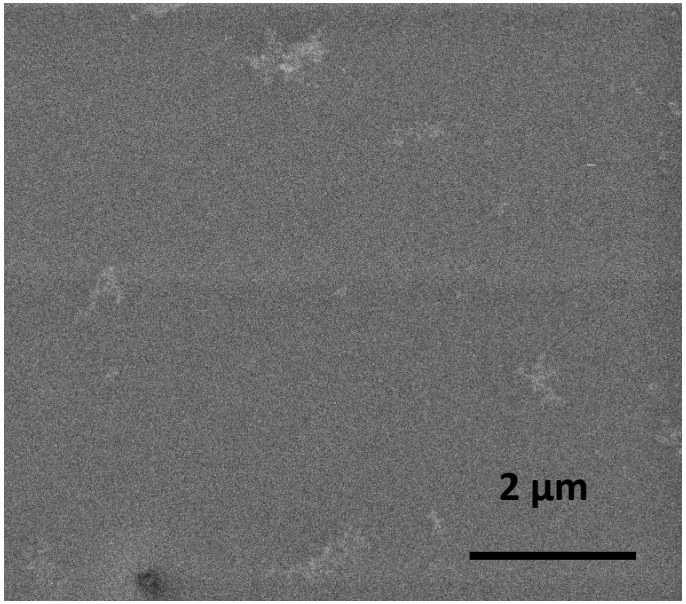


- Ag content +

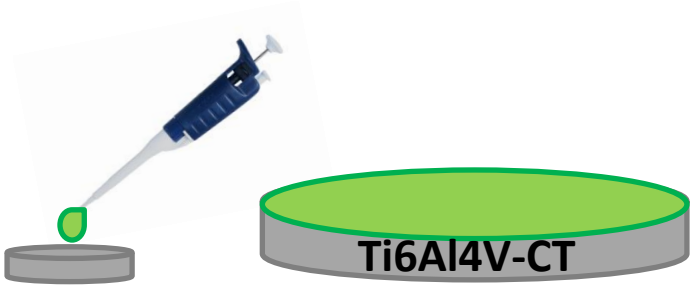


Chitosan from northern shrimp shells

Chitosan was obtained from northern shrimps shells (Genis hf).
Continuous coatings were obtained on chemically treated Ti6Al4V substrates.
Direct grafting to surface OH resulted in homogeneous, well adhered and stable coatings

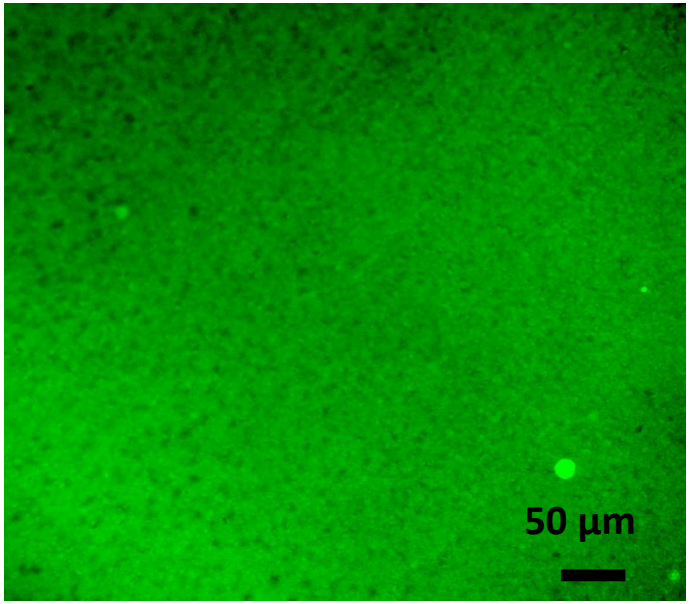


Peppermint essential oil (Pancalieri, Italy)



Homogeneous continuous coatings were obtained from pure oil deposition and polymerization

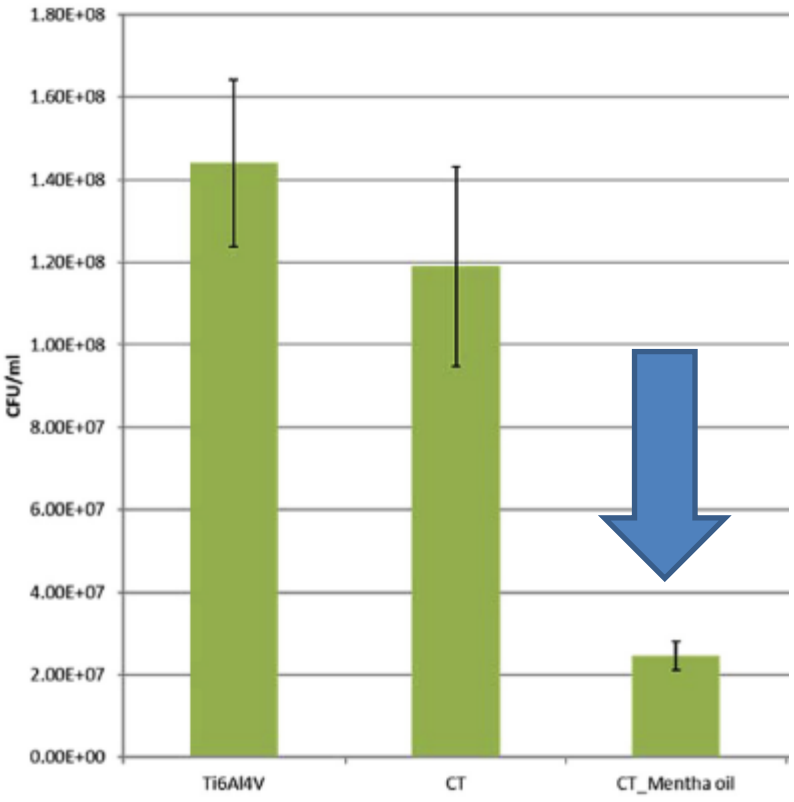
CT_Mentha oil



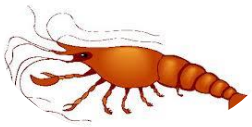
Fluorescence microscopy of peppermint essential oil coating on chemically treated (CT) Ti6Al4V alloy

M. Cazzola et al. Surface & Coatings Technology 378 (2019) 125011
M. Cazzola et al. Materials 13 (2020) 516; doi:10.3390/ma13030516

Peppermint essential oil (Pancalieri, Italy)



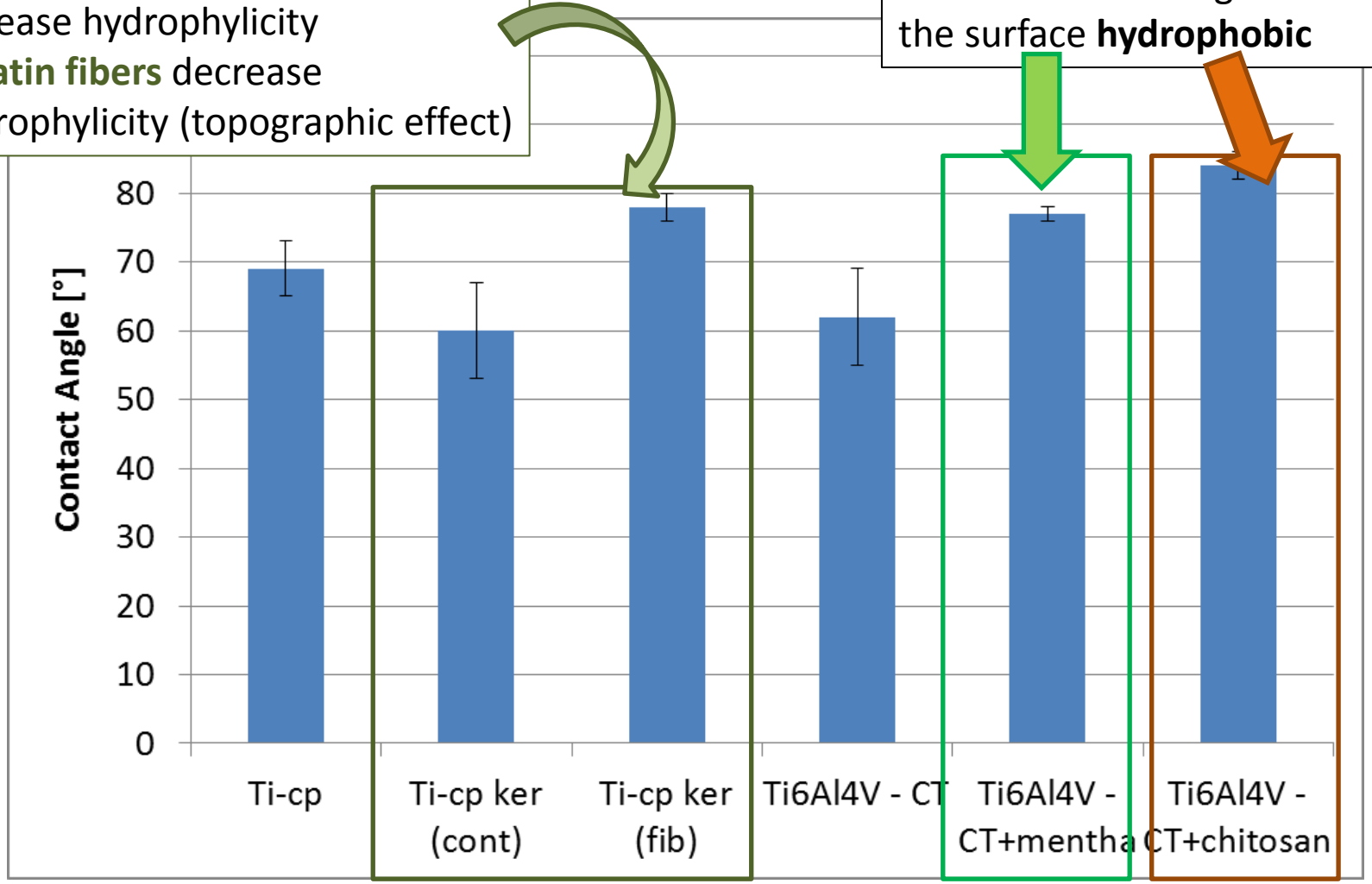
Reduction of Staphylococcus aureus adhesion on peppermint essential oil coated surfaces

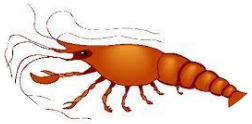




Keratin, chitosan and peppermint essential oil coatings: wettability comparison

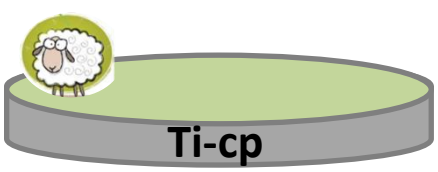
- **Keratin continuous coating** increase hydrophylicity
- **Keratin fibers** decrease hydrophylicity (topographic effect)

Chitosan and **peppermint essential oil** coatings make the surface **hydrophobic**

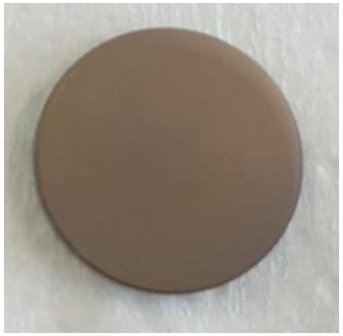
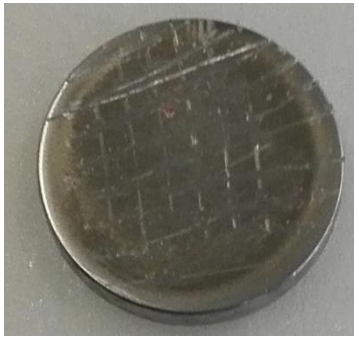
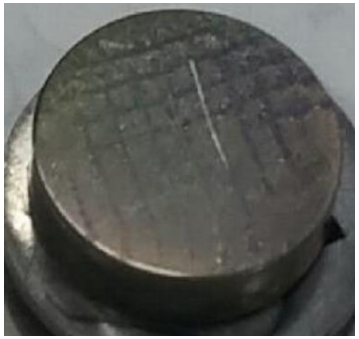



Keratin, chitosan and peppermint essential oil coatings: tape adhesion test comparison

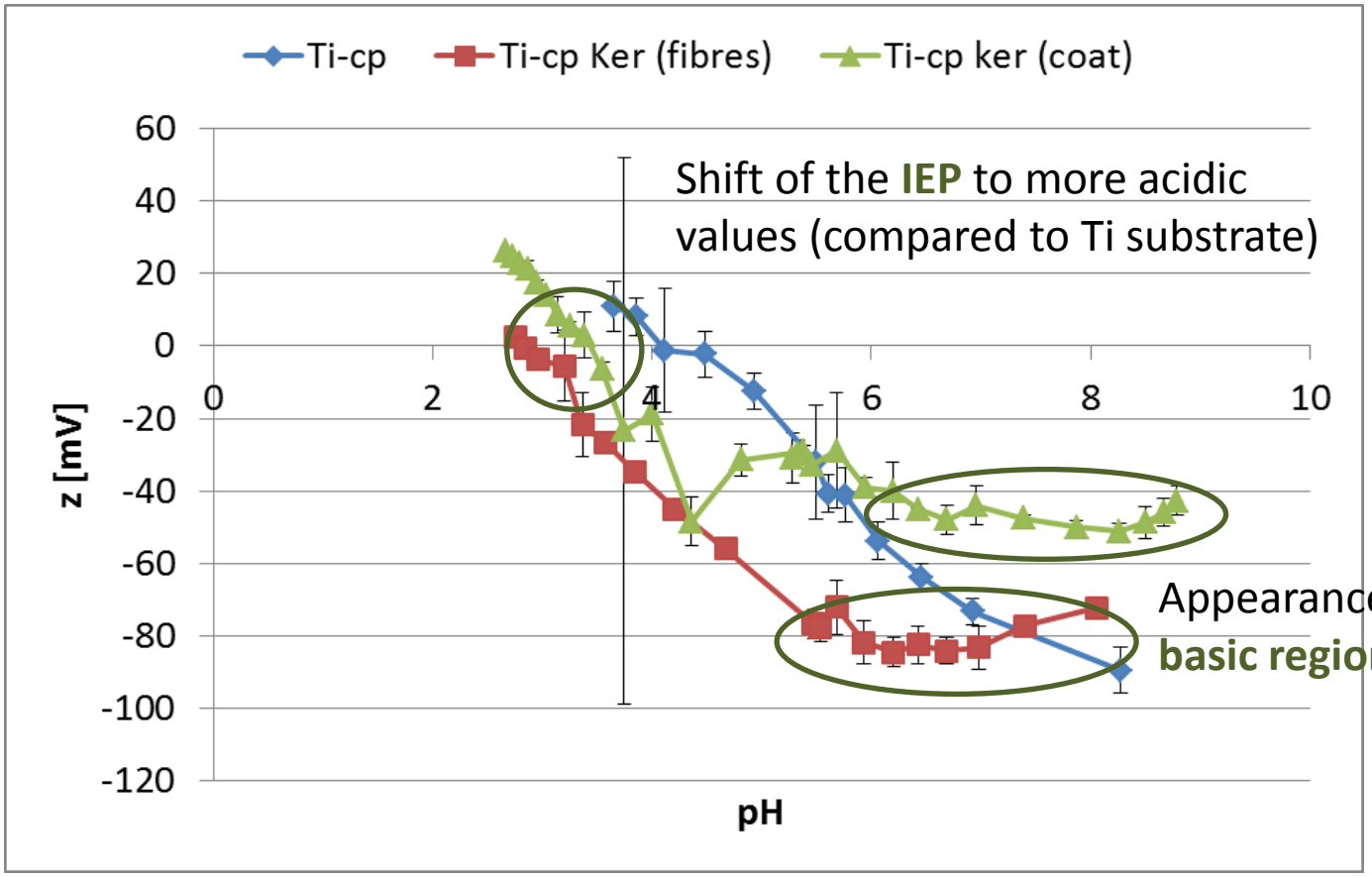




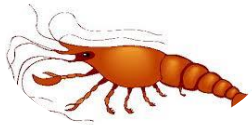

All the continuous coatings present an **optimal adhesion** to the substrate

Keratin from discarded wool: zeta potential titration



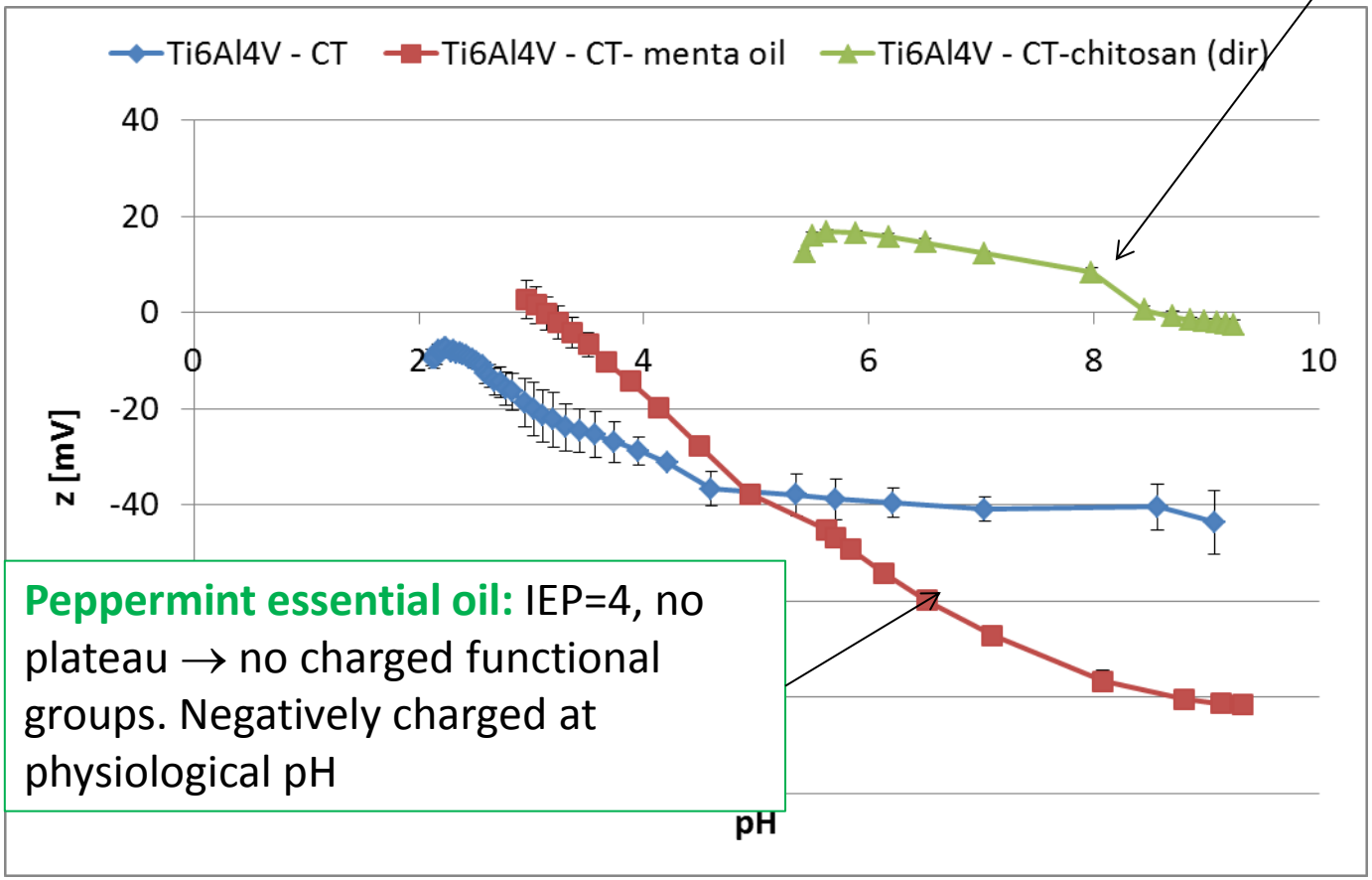
Low standard deviation (except for continuous coatings at pH=3,7)

Keratin coatings present acidic functional groups (COOH), are negatively charged at physiological pH and are stable through a wide range of pH)



Chitosan and peppermint essential oil: zeta potential titration

Chitosan: IEP=8,5, measurement in the acidic range impossible due to swelling, basic functional groups (NH_2). Positively charged at physiological pH



Peppermint essential oil: IEP=4, no plateau → no charged functional groups. Negatively charged at physiological pH

Conclusion

- ✓ Keratin, chitosan and peppermint essential oil coatings were successfully obtained on titanium surfaces.
- ✓ Keratin was obtained from discarded wool, chitosan from shrimp shells and peppermint essential oil from local production with a sustainable use of resources and promotion of local economies.
- ✓ The keratin coatings were hydrophilic while mint oil and chitosan coatings were hydrophobic.
- ✓ At physiological pH, keratin and mint oil coatings were negatively charged while chitosan ones were positively charged.
- ✓ The oriented keratin fibers were able to drive fibroblast alignment.
- ✓ Ag-doped keratin fibers and mint coating showed antibacterial properties.
- ✓ The here proposed natural coatings are promising for the improvement of the biological properties of titanium substrates with a sustainable use of the resources.