New inks containing silver nanoparticles for flexible sensors synthesis and characterization

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Flexible and stretchable printable electronics represent a promising research technology with applications in health, human-machine interaction, robotics, sensors, and consumer electronics.[1] In this work we describe the preparation and characterization of new inks containing silver nanoparticles for cost-effective printing solutions of flexible sensors for surface electromyography (sEMG), to record muscular activity.
The inks were synthesized by adapting some methods already described in literature.[2-3] In brief, silver nanoparticles were synthesized by preparing a 100 mL solution containing 0.5 g of polyvinylpyrrolidone (PVP, TCI) and 0.5 g of silver nitrate ($AgNO_3$, >99%, Sordalab), which were homogenized under vigorous stirring. Subsequently, 8 mL of a freshly prepared sodium borohydride ($NaBH_4$, >98%, Sordalab) solution at 10 mg/mL was added. The solution immediately acquired a brownish hue with silver tones and was stirred for approximately 10 minutes. Thereafter, it was filtered using a qualitative filter with a 10 µm pore size and centrifuged at 5000 rpm for 1 hour in polypropylene (PP) test tubes. The resultant deposit was dispersed in ethanol and subsequently analyzed. Different conductive inks were formulated based on the synthetized dispersions. The overall experimental workflow and a representative sEMG sensor prototype are shown in Figure 1.
To determine the nanoparticle concentrations, the dispersions were analyzed by measuring turbidance at 475 nm, using a UNICAM, Heλios α spectrophotometer. Given that viscosity critically governs the printing performance of the formulated inks, rheological measurements were carried out at 25 °C using a temperature-controlled Atago Visco 6800 viscometer. Preliminary results will be presented.

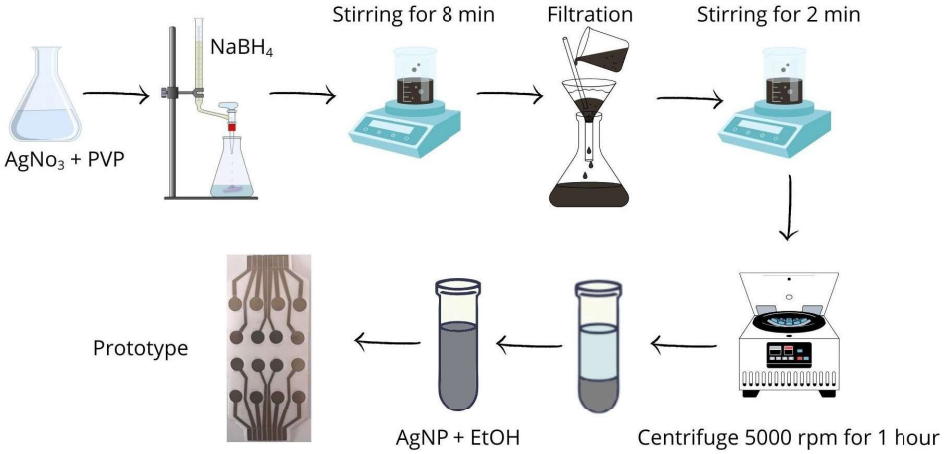

Figure 1: Method of synthesis including a sensor prototype.

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References

1. Rosati, G.; Cisotto, G.; Sili, D.; Compagnucci, L.; De Giorgi, C.; Pavone, E. F.; Paccagnella, A.; Betti, V. Inkjet-printed fully customizable and low-cost electrodes matrix for gesture recognition. *Nature Sci. Rep.* **2021**, *11*,14938.
2. Kosmala, A.; Wright, R.; Zhang, Q.; Kirby P. Synthesis of silver nano particles and fabrication of aqueous Ag inks for inkjet printing. *Mater. Chem. Phys.* **2011**, *129*, 1075–1080.
3. Polavarapu, L.; Manga, K. K.; Cao, H. D.; Loh, K. P.; Xu, Q. Preparation of conductive silver films at mild temperatures for printable organic electronics. *Chem. Mat.* **2011**, *23*, 3273–3276.