Carbon-Based Film Production via Electrospray Deposition

Arianna Parisi[a], Silvia Aita[a], Luciano Cortese[b], Claudia Basco[b], Raffaella Griffo[c], Claudia Carotenuto[c] & Francesco Di Natale [a]

[a] Università di Napoli Federico II – Dipartimento di Ingegneria Chimica, dei Materiali e della Produzione Industriale, Napoli, Italy

[b]Istituto di Scienze e Tecnologie per l'Energia e la Mobilità Sostenibili – Consiglio Nazionale delle Ricerche, Napoli, Italy

[c]Università della Campania L. Vanvitelli – Dipartimento di Ingegneria, Aversa (CE), Italy

e-mail: arianna.parisi@unina.it

Carbon-based materials have gained significant attention across various fields due to their exceptional physicochemical properties. These include high surface area, excellent electrical and thermal conductivity, chemical stability, tunable porosity, and the ability to be functionalized or doped with heteroatoms or noble metals. These attributes make them highly versatile for applications such as catalysis, gas sensing, fuel cell electrodes, energy storage, water treatment, and sensor technologies.

When processed into thin films, carbon materials offer functional surfaces suitable for integration in various devices. To be effective in industrial applications, these films must exhibit uniform thickness, surface homogeneity, strong substrate adhesion, mechanical robustness, and controlled wettability. Achieving these features depends strongly on the deposition method.

Electrospray deposition has emerged as a promising technique for producing nanostructured films with fine control over morphology and composition. It operates by applying a high voltage to a liquid suspension flowing through a needle, generating a cone-jet that produces charged microdroplets. These are deposited onto a grounded collector to form a film. Compared to conventional techniques like spin coating or airbrushing, the electrospray deposition provides superior control over film thickness, porosity, and reproducibility.

This study investigates the electrospray deposition of carbon-based films from ethanol-based inks containing commercial carbon powders and polyvinylpyrrolidone as a dispersing agent. The primary objective is to map the cone-jet stability domain by varying flow rate, applied voltage, and needle-to-collector distance. To further enhance deposition throughput, a bipolar configuration is also explored, where the collector is biased with a voltage of opposite polarity to the needle. This setup increases the electric field intensity and may stabilize the cone-jet mode at higher flow rates. Once optimal conditions are defined, carbon films are deposited and characterized. Scanning Electron Microscopy is used to assess surface morphology and homogeneity, while contact angle measurements evaluate wettability. Additionally, a rheological analysis of the deposited films is proposed to study cohesion, mechanical stability, and film-substrate interactions, offering new insights into film performance.

These findings highlight that the carbon-based films fabricated via electrohydrodynamic deposition represent viable materials for next-generation energy and sensing systems.

Keywords: *electrospray deposition, carbon-based nanostructured films, cone-jet, electrohydrodynamic atomization.*