Scientists develop efficient spray technique for bioactive materials

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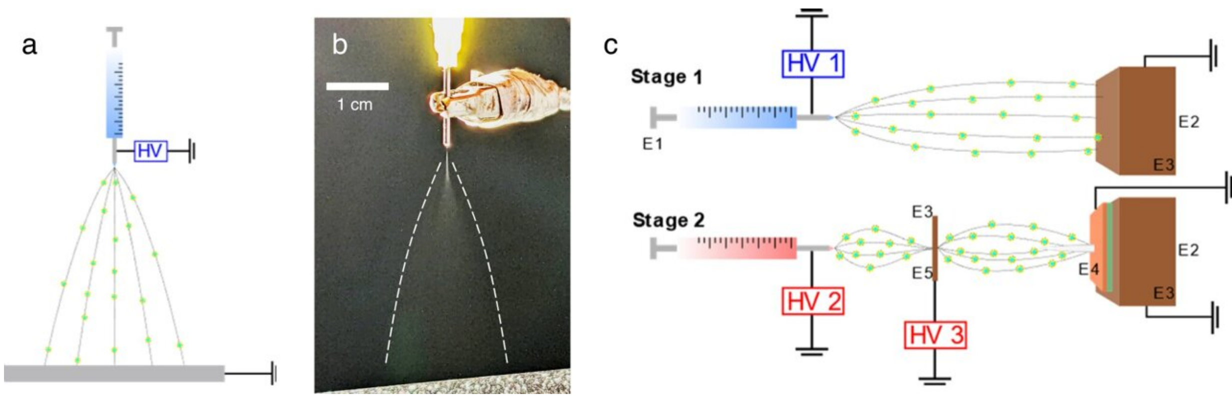


Schematic and b photograph of an ESD experiment where a spray plume directed at a grounded target is generated from a solution reservoir held at high voltage. White dashed lines are provided as a guide to the eye of the plume. c Schematic of the spray system and process, highlighting different enhancements (denoted 'EX'). In stage 1, a negative polarity ethanol spray (E1) is sprayed directly at a large extractor ground (E2) which is coated in insulating Kapton tape (E3). While the focus ring is in place during this treatment, no clip is applied and thus it is not electrified or grounded. Then in stage 2, a grounded target with an insulating mask (E4) is placed on the extractor ground. It is then sprayed by the spray solution at positive polarity which is stabilized by a focus ring (E5). The ring, and all other proximate metal surfaces, is also coated in insulating tape. Credit: *Nature Communications* (2023). DOI: 10.1038/s41467-023-40638-7

Rutgers University scientists have devised a highly accurate method for creating coatings of biologically active materials for a variety of medical products. Such a technique could pave the way for a new era of transdermal medication, including shot-free vaccinations, the researchers said.

Writing in *Nature Communications*, the researchers described a new approach to electrospray deposition, an industrial spray-coating process. Essentially, the team developed a way to better control the target region within a spray zone as well as the electrical properties of microscopic particles that are being deposited. The greater command of those two properties means that more of the spray is likely to hit its microscopic target.

In electrospray deposition, manufacturers apply a high voltage to a flowing liquid, such as a biopharmaceutical, converting it into fine particles. Each of those droplets evaporates as it travels to a target area, depositing a solid precipitate from the original solution.

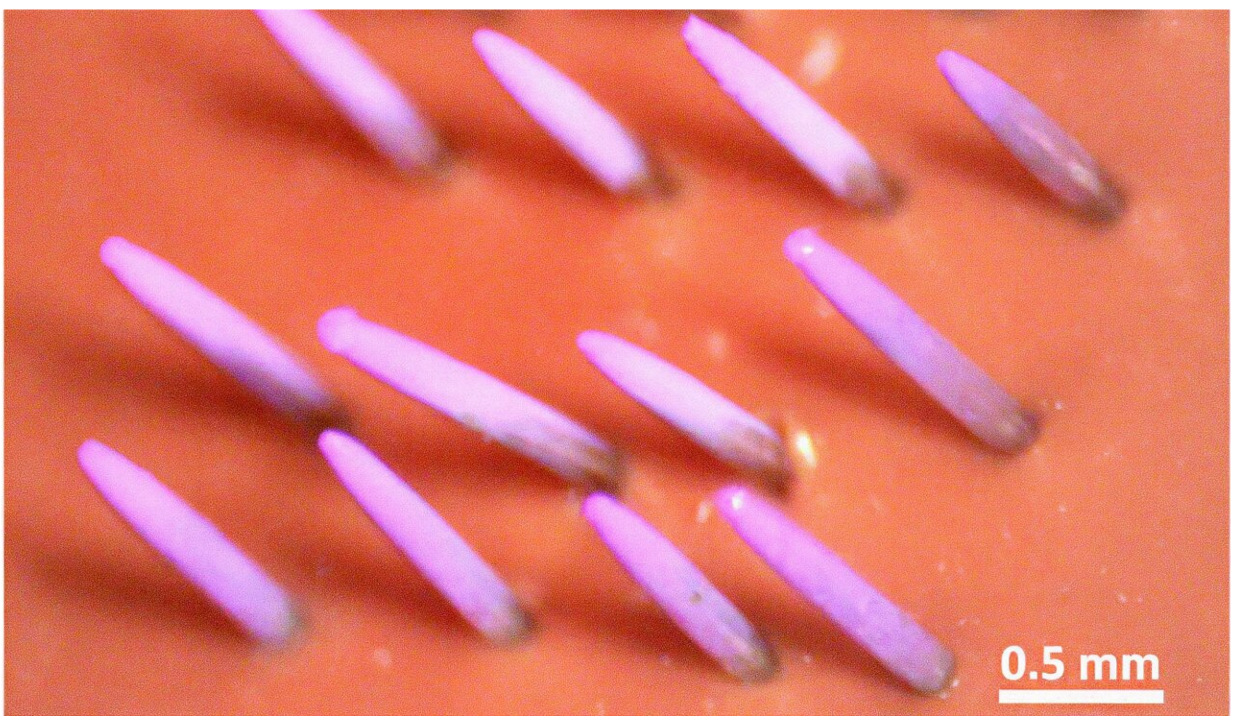
"While many people think of electrospray deposition as an efficient method, applying it normally does not work for targets that are smaller than the spray, such as the microneedle arrays in transdermal patches," said Jonathan Singer, an associate professor in the Department of Mechanical and Aerospace Engineering in the Rutgers School of Engineering and an author on the study. "Present methods only achieve about 40% efficiency. However, through advanced engineering techniques we've developed, we can achieve efficiencies statistically indistinguishable from 100%."

Coatings are increasingly critical for a variety of medical applications. They are used on medical devices implanted into the body, such as stents, defibrillators and pacemakers. And they are beginning to be used more frequently in new products employing biologicals, such as transdermal patches.

Advanced biological or "bioactive" materials—such as drugs and vaccines—can be costly to produce, especially if any of the material is wasted, which can greatly limit whether a patient can receive a given treatment.

"We were looking to evaluate if electrospray deposition, which is a well-established method for analytical chemistry, could be made into an efficient approach to create biomedically active coatings," Singer said.

Higher efficiencies could be the key to making electrospray deposition more appealing for the manufacture of medical devices using bioactive materials, researchers said.



Dyed DNA vaccine coated on a microneedle array by efficient electrospray deposition. Credit: Sarah H. Park/Rutgers School of Engineering

"Being able to deposit with 100% efficiency means none of the material would be wasted, allowing devices or vaccines to be coated in this way," said Sarah Park, a doctoral student in the Department of Materials Science and Engineering who is first author on the paper. "We anticipate that future work will expand the range of compatible materials and the material delivery rate of this high-efficiency approach."

In addition, unlike other coating techniques used in manufacturing, such as dip coating and inkjet printing, the new electrospray deposition technique is characterized as "far field," meaning that it doesn't need highly accurate positioning of the spray source, the researchers said. As a result, the equipment necessary to employ the technique for mass manufacturing would be more affordable and easier to design.

Other Rutgers scientists on the study included professors Jerry Shan and Hao Lin, former doctoral students Lin Lei (now at Chongqing Jiaotong University) and Emran Lallow (now at GeneOne Life Science, Inc.), and former undergraduate student Darrel D'Souza, all of the Department of Mechanical and Aerospace Engineering; and professors David Shreiber and Jeffrey Zahn, doctoral student Maria Atzampou, and former doctoral student Emily DiMartini, all of the Department of Biomedical Engineering.

More information: Sarah H. Park et al, Efficient electrospray deposition of surfaces smaller than the spray plume, *Nature Communications* (2023). DOI: 10.1038/s41467-023-40638-7

Provided by Rutgers University

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