ABSTRACT

Microneedle is an innovative technology of drug delivery that increases the permeability of the skin. It generates microscopic pores inside the skin over which passive diffusion of drug to dermal microcirculation takes place. Microneedles are small size needles usually in the micron range having lengths of about 20-500 µm respectively. The tip diameter of microneedles varies from 5-25µm which can pierce through the stratum corneum to the epidermis layer devoid of any pain. Different materials like metals, sugars, polymers, silicon, etc. have been used for fabrication. Various fabrication techniques have been used for their fabrication, including laser ablation, lithography, injection molding, additive manufacturing, etc. The tip diameter of different micron ranges has been achieved. The strength and stiffness of the microneedle's tip have always been important in fabricating microneedles so that it doesn't break on insertion. This work uses numerical analysis using the fuzzy approach, structural simulation, and fabrication analysis for three different solid microneedles. Firstly, structural simulation has been performed in ANSYS software to test the strength of gold (Au), silver (Ag), and copper (Cu) microneedles separately. The purpose is to compare the stress effect and fracture limit of all microneedles. Then fuzzy-based numerical analysis has been performed in MATLAB software for all solid microneedles separately. In this numerical analysis, the effect on the range of microneedle tip diameter and needle length has been observed by varying input voltage and time. This numerical analysis is useful for fabrication. Finally, fabrication has been performed using a novel economical technique such as the chemical method. It is a very low-cost and clean room-free technique as compared to other techniques used for the fabrication of microneedles. The fabrication technique adopted in this work is the same for gold, silver, and copper microneedles. The SEM characterization has been performed afterward. The tip of the fabricated solid Au, Ag, and Cu microneedle has been then coated with drugs using the dip-coating method. The axial force test has been then performed on fabricated microneedles to check the strength of the tip. The results of this present research provide valuable benchmark and prediction data to fabricate solid microneedles with innovative fabrication techniques and materials which haven't been used before for solid microneedles.