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An investigation into the porosity and permeability properties of fabric materials using nanotechnology and fractal geometry

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Nowadays, nanotechnology is used in the apparel industry for manufacturing fabrics with enhanced physical properties, for example, with a higher level of comfort and antiviral characteristics than traditional approaches. Fractal geometry, on the other hand, is very useful for studying the surfaces of irregular shapes with complicated structural patterns making it straightforward to describe, model, and analyse such natural irregular complex structures. The main objective of the present study is to develop a mathematical model for the pore area fractal dimension of fabrics while controlling the porosity and permeability and then use that built-in connection and nanotechnology to investigate how fabrics can be improved to give maximum comfort while providing maximum protection to the user from different viruses. We used different structural patterns for fabrics such as plain woven, four-harness, and bidirectional stitched fibre mats with fractal characteristics in the irregular structure of the porous medium. An expression for the pore area fractal dimension of fabrics was developed using the unit cell concept. A relationship between porosity and permeability of fabrics was derived by combining Darcy's law and the Poiseuille equation together with the fractal dimension. It was studied how the permeability of fabrics increases/decreases with its porosity. Finally, it should be noted that the derived mathematical expression can be applied to materials used for the manufacture of face masks to study how to reduce the risk of viral penetration further.

Keywords: Porosity and permeability, Darcy's law, Poiseuille equation, nanotechnology, Fractal geometry

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