Systematic analysis for electrical conductivity of network of conducting rods by Kirchhoff's laws and block matrices

김동재[1,2,†], 남재욱[2]
[1]서울대학교 공학연구원; [2]서울대학교 화학생물공학부
(ssdj91@nate.com[†])

The study presents a systematic analysis of the electrical conductivity of a network of conducting rods. When a voltage source is loaded on the network, the network can act as an electrical circuit. To analyze the circuit, we used graph theory and Kirchhoff's laws. Using multi-nodal representation, we properly assigned nodes and edges to the circuit, and used an incidence matrix to translate the circuit to a mathematical expression. Combining the incidence matrix with Kirchhoff's law, the electrical variables, including current and electrical potential, were formulated by the block equation. Since the equation can be partitioned into several block matrices based on the origin of the nodes and edges, we derived simple and explicit relations between the variables and the network structures by manipulating the block matrix. To evaluate the effect of the networks, we introduced a normalized conductivity, deduced from the above relations. We also found a new parameter, namely the normalized number of edges (NNE), that is directly related to the electrical conductivity. Also, we figured out the NNE is a function of the number density of rods in the circuit.