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Surface electrical properties of model membrane structures in the presence of neurotransmitters

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Acting as chemical signals neurotransmitters are expected to influence biological membranes' electrical properties, related to the transmission of electrical impulses and the interaction of cells with external electric fields. Closed membrane structures such as erythrocytes represent model system successfully exploited in the investigation of the electrical properties of biological membranes. In the present study we address the effect of dopamine on the electrokinetics properties of erythrocytes to deduce their structural changes and the surface charge density of their membranes. Dopamine is one of the most important neurotransmitters, both excitatory and inhibitory. Its motor and motivational behavior dysfunction is involved in psychiatric disorders such as drug addiction, schizophrenia, Parkinson's and Huntington's disease.

The effect of dopamine on erythrocytes and model lipid bilayers is characterized by investigating their electrokinetic parameters, mechanical properties and lipid peroxidation. Erythrocytes in the presence of 0.005 mM dopamine have increased zeta potential and surface electric charge. In the presence of 0.010 mM dopamine in the erythrocyte suspension, a decrease in the zeta potential by about 2 mV and a decrease in the negative surface electrical charge are observed. Erythrocytes are also characterized by a greater increase in zeta potential and surface charge when treated with 0.02 mM, 0.10 mM and 0.40 mM dopamine. A similar increase in the electrophoretic mobility, zeta potential and surface electrical charge in the presence of 0.2 mM dopamine in the erythrocyte suspension is observed, followed by a slight decrease in zeta potential in the presence of 0.05 - 0.30 mM dopamine. Higher dopamine concentrations of 10 mM and 15 mM lead to strong aggregation and reduction in the zeta potential and the negative charge density of the erythrocyte membrane.

With increasing dopamine concentrations (5 - 40 mM), an increase in lipid peroxidation from the erythrocyte membranes is observed. Significantly lower is the increase in TBARS products after exposure to 1 - 4 mM dopamine or 0.3 mM dopamine on erythrocyte membranes. A protective effect of dopamine is observed in the concentration range of 0.005 - 0.040 mM, where a reduction of lipid peroxidation by erythrocytes is observed. These data suggest that lipid peroxidation is not involved in the mechanism underlying dopamine alteration of electrokinetic properties of erythrocytes. The role of the surface charge of erythrocytes in affecting its aggregation by neurotransmitter is studied by comparing the behavior of normal erythrocytes with that of cells treated with dopamine which alter the zeta potential and oxidative stress status.

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