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

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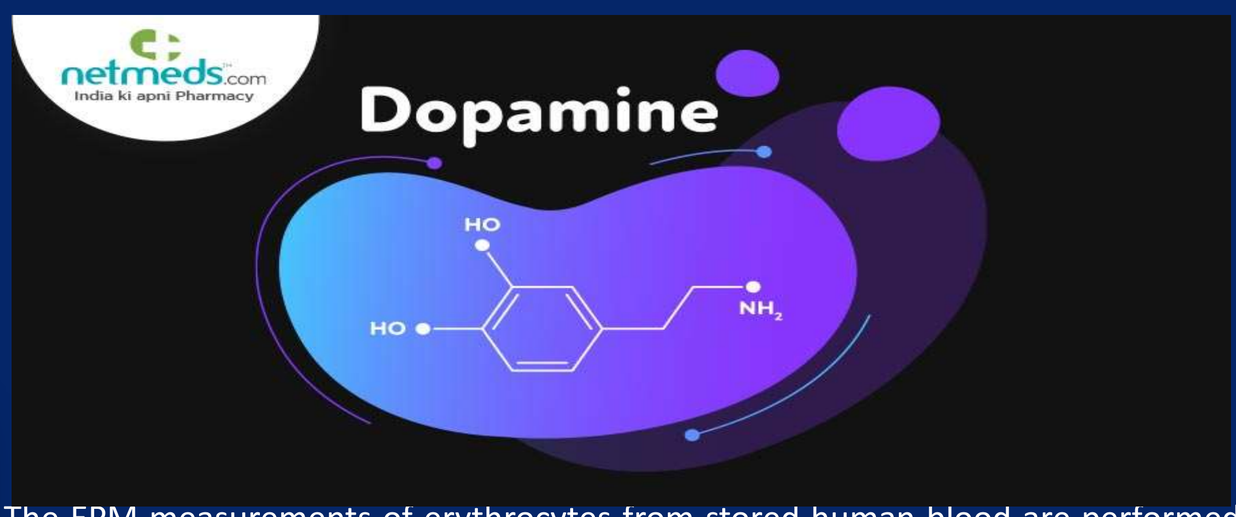
ABSTRACT

Surface electrical charge is a key factor for the functional activity of biological membranes induced by neurotransmitters treatment. 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.

INTRODUCTION

Neurotransmitters have modulatory functions and can alter the efficacy of chemical synapses by acting either on specific steps in the junctional transmission process or on intrinsic membrane properties of the postsynaptic cell. The nerve terminal is a specialized region of the neuron, releasing neurotransmitter upon activation by an electrical signal carried by the axon. Erythrocytes, isolated from human blood, have greatly improved our knowledge of biochemical aspects of dopamin action on cells. They have been used to determine electrokinetic potentials on the outer surface of the membrane.

MATERIALS AND METHODS

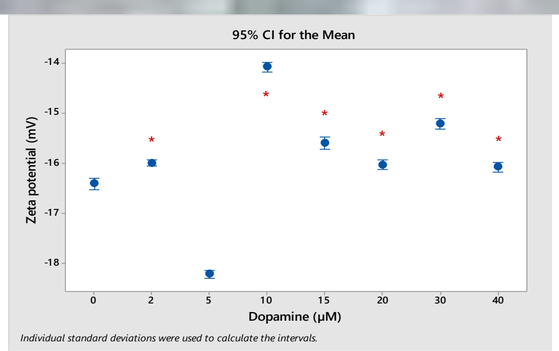


The EPM measurements of erythrocytes from stored human blood are performed using the particle electrophoresis technique with the OPTON Cytopherometer (Germany). The values of zeta potential (ζ) are calculated by Helmholtz-Smoluchowski formula. The surface charge density is determined according to MacLaughlin (1977). Lipid peroxidation studies are conducted with an apparatus using S-200 Spectrophotometer (Germany).

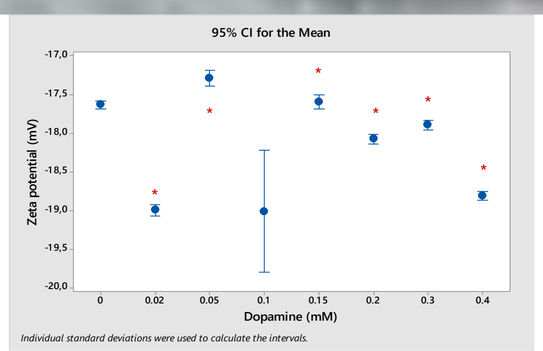
AIM OF THE STUDY

The purpose of the current work is to study the effects of L-Dopamine on the surface electrical charge of human erythrocytes. In the study we have applied the electrokinetic approach to examined electrophoretic mobility (EPM) using microelectrophoresis method and Lipid peroxidation assay). The effect of dopamine on erythrocytes is characterized by investigating their electrokinetic parameters and lipid peroxidation.

RESULTS AND DISCUSSION



Individual standard deviations were used to calculate the intervals.



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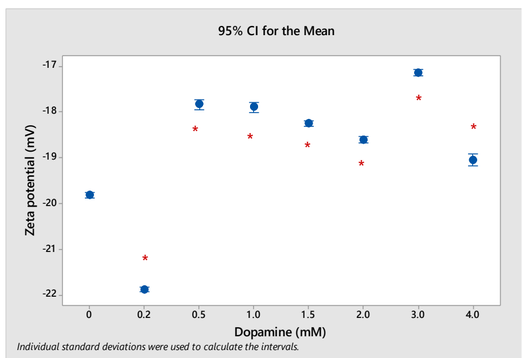

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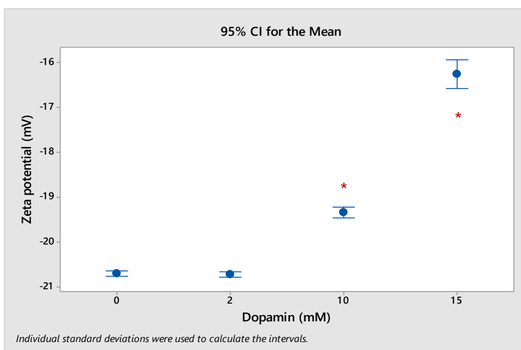

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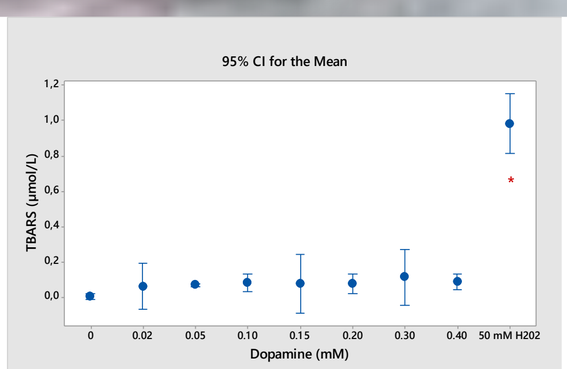

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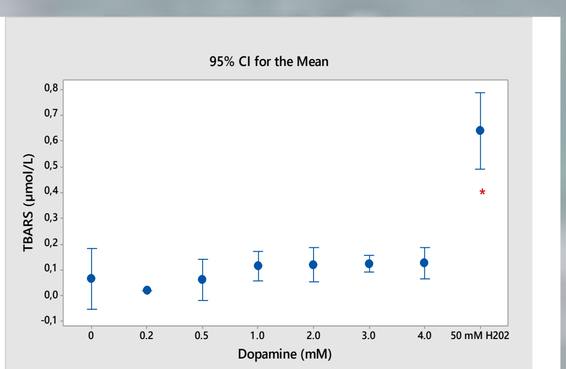

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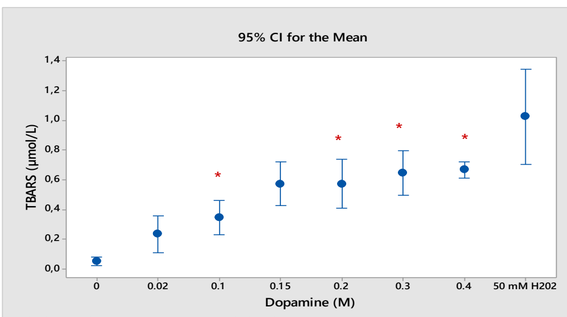

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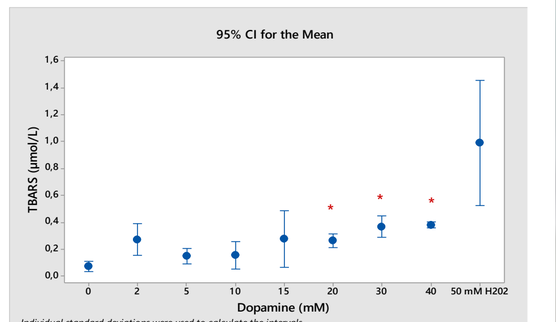

Individual standard deviations were used to calculate the intervals.

Erythrocytes are also characterized by a greater increase in zeta potential and surface charge when treated with 0.02 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 membrane 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.

L-Dopamine is a water-soluble weakdipole amine, that, due to the secondary amino groups, is acting as weak alkali. This property of Dopamine plays an important role in its binding to the receptor protein in the dopaminergic site of the membrane surface that possesses negative overcharge. L-Dopamine doses of (0.2 μM - 4 mM) decrease the surface electrical charges of erythrocyte membranes, while the free radical products changes in the presence of 0.2 – 0.4 mM Dopamine are enhanced.

CONCLUSIONS

It may be concluded that the incorporation of L-Dopamine into erythrocyte membranes leads to alteration of the topography and the structural relief of the charge, but to significant structural conformational transformations due to changes in cell behavior in the electric field and the physiological alterations observed in the blood.

ACKNOWLEDGEMENTS

This work is supported by Grant № KP-06-38/14/2019 from the Bulgarian National Science Fund, Ministry of Education and Science, Bulgaria.