

Removal of erythrocyte ghosts from biological media by means of electrochemically modified activated carbon

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Trauma and destruction of the formed elements of blood due to various causes has continually been a subject of great interest in biomedical research. E.g., hemolysis (the destruction of red blood cells) and the subsequent appearance of hemoglobin in blood plasma occur as a result of mechanical injury to the membranes of erythrocytes, which may occur with the use of a pump oxygenator during lengthy surgical procedures.

One of the most harmful consequences of hemolysis is the presence of the hemolyzed erythrocytes that no longer contain hemoglobin (so-called “ghost cells”) in the bloodstream. Increasing amounts of erythrocyte ghosts in blood can lead to renal failure, as the relatively large ghost cells (6-8 μm) are unable to perfuse through the glomerular capillaries in the kidney (with a diameter of *ca.* 4 nm). This makes the removal of ghost cells from blood an important problem, one that has not been solved to date.

Based upon the previously proposed electrochemical model of blood cell interaction with activated carbons [1], a process of separation of ghost cells from untraumatized blood cells by using electrochemically modified activated carbon was proposed. To test the proposed process, adsorption of erythrocyte ghosts from partly hemolyzed packed red blood cells (RBC) on electrochemically modified FAS activated carbon (with potentials between -460 and $+290$ mV) was investigated. Potentials between -200 and $+50$ mV corresponded to a nearly complete elimination of the ghost cells from RBC (Fig. 1).

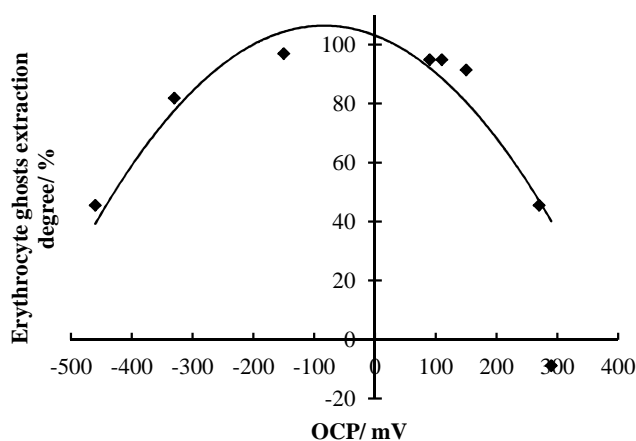


Fig.1. Erythrocyte ghost adsorption on activated carbon

Importantly, the erythrocyte ghosts were selectively removed from RBC, with no concurrent reduction in the count of normal erythrocytes. This shows that electrochemically controlled sorption on modified activated carbons is a new, viable method of separation of normal and “ghost” erythrocytes. It should be noted that

erythrocyte ghosts adsorb exclusively in the macropores of the activated carbon due to their physical dimensions. The presence of ghost cells on the surface of carbon is shown in Fig. 2.

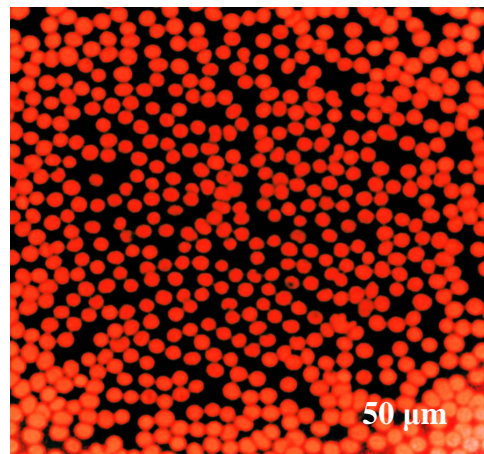


Fig. 2. Fluorescence microscopy of stained erythrocyte ghosts on the surface of FAS activated carbon after contact with partly hemolyzed RBC

As shown previously [1], activated carbons are indifferent toward blood when their potential is in the range between -100 and $+50$ mV. Thus, the potential range of maximum ghost cell adsorption on the FAS carbon identified in the present work is quite compatible with its practical use in hemoperfusion or other biomedical applications.

Morphometry of the red blood cells after contact with the surface of FAS carbon showed little to no erythrocyte aggregation, whereas the initial packed red blood cells did show aggregation of erythrocytes. Additionally, while normal erythrocyte morphology was largely absent from the hemolyzed RBC, it appeared well distinguishable in the RBC after contact with the FAS carbon.

The latter observation is strong evidence for stabilization of normal erythrocytes upon contact with the polarized activated carbon. This can be rationalized by the likelihood of adsorption of the contents of lysed blood cells along with the adsorption of ghost cells, since the former can promote aggregation of erythrocytes.

Additionally, since the surfaces of activated carbon and the membrane are charged, the collisions of red blood cells with the carbon surface can be accompanied by a transfer of charge. Indeed, modified activated carbon with potentials between -617 to $+85$ mV experienced positive shifts of potentials of up to 15 mV. This suggests the occurrence of electron transfer from the carbon surface to the cell membranes in the course of the collisions.

1. Mark M. Goldin, A.G. Volkov, Yu.S. Goldfarb, Mikhail M. Goldin, Electrochemical aspects of hemosorption, *Journal of the Electrochemical Society* 153(8):J91-J99 (2006)