Partial wetting of porous substrates by blood droplets

[Abstract]

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Dried blood spots (DBS) is a high potential blood collecting and sampling method which provides several advantages in blood sample collection, storage and transportation against conventional whole blood collection or plasma collection. The principle of DBS application is as follows: using a thin porous substrate, such as cotton fibres, cellulose fibres and polymer membrane etc., as an absorbent sponge where blood droplet from a fingertip or syringe is collected and the blood preserved as a dried spot sample. Therefore, the whole process of DBS sampling could be considered as spreading of non-Newtonian fluid (blood drop) over porous substrate (DBS card) with simultaneous spreading and penetration inside the porous substrate.

The spreading and wetting of porous substrate by blood are complex process depending on the physical and chemical properties of both a substrate and a liquid. This process has been investigated in the case of spreading/imbibition of Newtonian liquids [1, 2] and in the case of blood (non-Newtonian liquid) spreading/imbibition [3, 4] when liquid wets completely the porous substrate. Here the spreading behaviour of DBS sampling has been investigated in the case of partial wetting. Nitrocellulose membranes (NCM) with different pore size and silanized Whatman 903 blood saving card have been used as porous substrates. The spreading experiments have been applied to obtain the time evolution of spreading parameters, such as, radius of droplet base and wetted region, and dynamic contact angle.

The result of spreading on NCM showed that the spreading process was a partial wetting spreading with three subsequent stages as shown in Fig. 1: initial fast spreading, constant maximum droplet base and the shrinkage of the drop base. However, in spite of silanization of the Whatman 903 filter paper, the blood droplet showed a complete spreading behavior with two subsequent stages: initial fast spreading and the shrinkage of the drop base. A separation of red blood cells (RBCs) and blood plasma has been found in the case of the blood drop spreading over 0.2 and 3.0 µm NCMs in which the RBCs are mostly collected on the membrane surface and plasma is collected inside the membrane pores. Important that the RBCs were not damaged in this process. This opens a completely new opportunity to (1) investigate RBCs and plasma separately; (2) to use this method for non-destructive separation of living cells from aqueous solutions.

FIG. 1. Dimensionless radius of the droplet base in the case of spreading over NCM.