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## Short communication

# The fouling and cleaning of venous catheters: A possible optimization of the process using intermittent flushing

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## A B S T R A C T

The aim of this note is to report experimental results obtained for mass transport under controlled flow conditions in a system where convection and diffusion are coupled with chemical interactions associated to the protein adhesion. The context of the problem is of crucial practical importance in the framework of medical application and is concerned with the maintenance of central venous catheters. Then a phenomenological description is suggested giving a possible description of the process.

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## 1. Introduction

In many industrial activities, the fouling can become a very serious problem if cleaning processes are incorrectly designed or operated improperly. In recent years, considerable attention has been paid to understanding the processes involved in the formation and removal of deposits in order to extend the operating period between cleanings, and to improve the efficacy of cleaning methods. This is notably the case of studies on proteins and deposition of calcium phosphate in the milk industry (Changani et al., 1997; Gillham et al., 2000) and scale deposition in heat exchangers (Georgiadis and Papageorgiou, 2000; Georgiadis et al., 2000; Jamialahmadi and Muller-Steinhagen, 2007)

Fouling in the food and medical industry is more severe than in other industries because of the nature of deposits (such as protein or pathogenic bacteria) which require frequent or immediate cleanings for public health problems. For such industrial activities, specific protocols have been developed as for example the technique of flow pulsing which have showed recently an enhancement of the rate of cleaning proteins (Christian and Fryer, 2006; Augustin et al., 2010). Experiments on cleaning of whey protein show that

an up to 50% shorter cleaning time is achievable when pulsed flow is applied (Gillham et al., 2000; Bode et al., 2007).

The administration of medicines or solutes by means of peripheral or central venous catheterization is a frequent practice that covers a wide variety of situations. Among the different acts of maintenance of the catheter the flushing holds a key position with a crucial objective: to avoid the occlusion of the device. Although it comes from the literature that the efficiency of the cleaning appears to be more dependent on the technical practice (standardized procedure, bolus, and positive pressure) than on the used solute (Garrelts et al., 1989; Goode et al., 1991; Smith et al., 1991; Thunder Project, 1993; Therapeutic position statement, 1994; McEvoy, 2001; Pierre, 2003; Replinger et al., 2004), only a few papers give a description of the techniques (Booker and Ignattavicius, 1996; Coquin and Vigier, 2002) and no one gives a description of the way for administration.

In the framework of practical applications the Reynolds numbers of the flows in the catheters are in the range  $2 < Re < 1500$ , the lower values of  $Re$  being associated with flushing by perfusion and the higher to manual flushing with calibrated syringes of 10 ml.

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