Poly(3,4-ethylenedioxypyrrole) – biocompatible matrix for local drug delivery systems

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Introduction

In the past few years local drug delivery systems became very popular methods of treatment, making this process easier and more effective. Since conducting polymers are extensively studied in the field of biosensors, artificial scaffolds and neural probes, they are supposed to be promising materials for controlled drug delivery systems. Two most popular conducting polymers exhibiting biocompatibility are polypyrrole (PPy) and poly(3,4-ethylenedioxytiophene) (PEDOT). Recent literature reports indicate poly(3,4-ethylenedioxypyrrole) (PEDOP) as an ideal candidate as material for biomedical engineering, mainly because of its biocompatibility. PEDOP combines the most desirable properties of PPy and PEDOT: it has lower polymerization potential than PEDOT and, simultaneously, is more stable than PPy.

In this study, we present one of the first efforts to utilize PEDOP for the immobilisation of drugs. Two model drugs have been chosen – quercetin (Que) and ciprofloxacin (Cipro). Quercetin is one of flavonoid drug with wide spectrum of activities. Ciprofloxacin mainly treats bacterial infections caused by Gram-positive and Gram-negative bacteria.

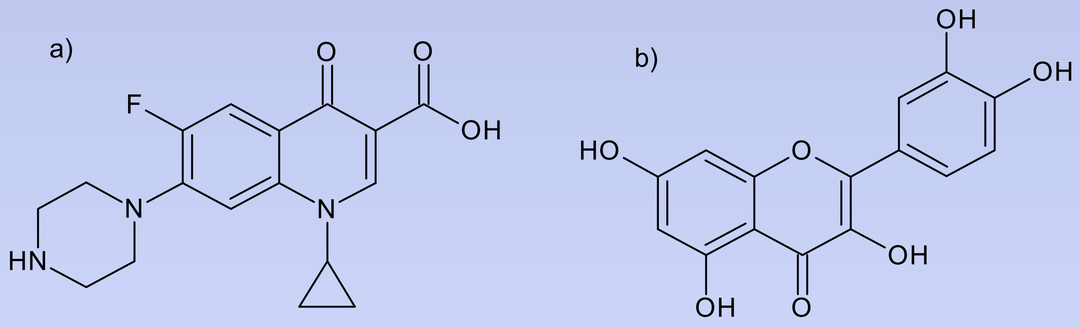

Figure 1. Model drugs immobilised in PEDOP matrix : a) ciprofloxacin, b) quercetin.

Methods

Drug immobilisation was performed via two methods – one step immobilisation and three steps immobilisation. In one step method, EDOP was electropolymerised in the presence of quercetin or ciprofloxacin. In three step method, drugs were immobilised as the result of the ion-exchange process on PEDOP matrix. Drug release process was performed by immersing polymer matrix in electrolyte solution (passive mode) or by the application of constant potential -0,7 V (active mode). The efficiency of controlled release of drugs was studied with UV-Vis spectroscopy. The morphology of PEDOP matrices was investigated by SEM.

Discussion

Ciprofloxacin and quercetin have been successfully immobilised in PEDOP matrix via one step method. After the process of immobilisation, cyclic voltammetry has been utilized to study the electrochemical behaviour of drug-modified layers. Cyclic voltammograms presented in Fig.2. show that PEDOP/Cipro and PEDOP/Que are evidently thinner than pure PEDOP film, but they are still able to conduct electricity. The influence of the film thickness on the amount of drug released is presented in Fig. 3.

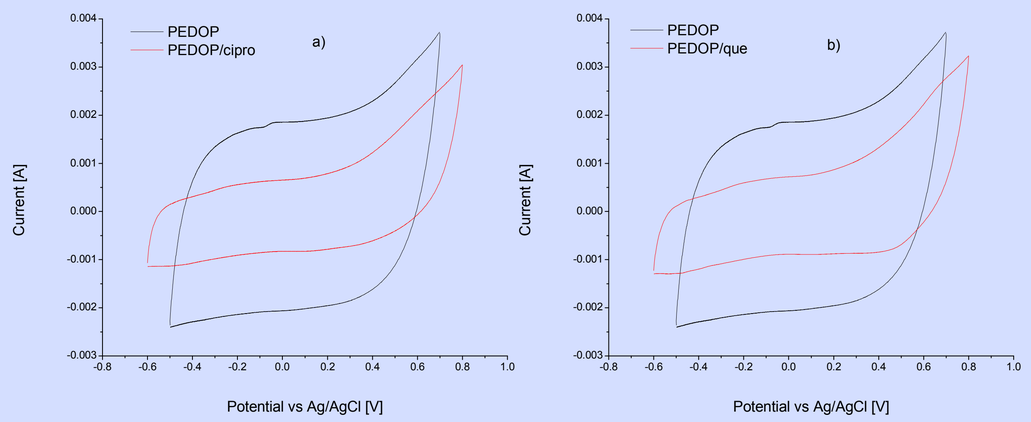

Figure 2 Cyclic voltammograms for PEDOP, PEDOP/Cipro and PEDOP/Que. Drug immobilisation has been performed via one step method.

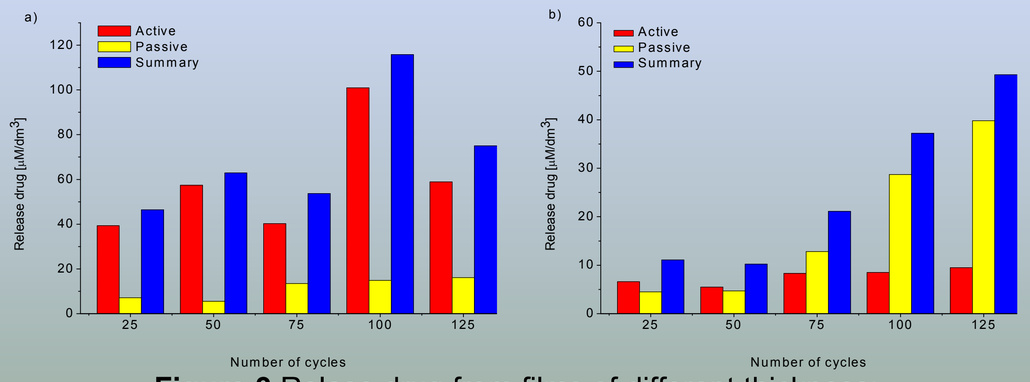

Figure 3 Relase drug from films of different thickness: a) PEDOP/Cipro, b) PEDOP/Que.

Three steps immobilisation has been also observed to lead to the immobilisation of model drug, ciprofloxacin. This time, however, more drug has been released from thinner polymer layers (Fig. 4 a,b). Because of the fact that in three step immobilisation method drug molecules are incorporated only in the surface region of polymer matrix, thinner layers are supposed to perform more efficiently than thicker ones.

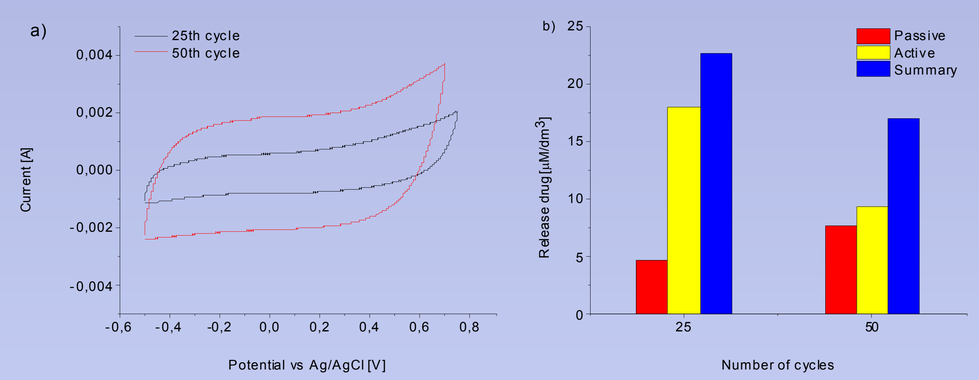

Figure 4 CV curves of EDOP electropolymerisation (a) and the amount of released ciprofloxacin (b).

As the immobilisation of drug changes the structure of the polymer, it is suspected that the morphology of drug-modified layers will be different from the morphology of PEDOP. Fig. 5 shows SEM images of PEDOP/Que and PEDOP/Cipro films after two drug immobilisation procedures and after different stages of drug release, namely before and after passive and active release modes.

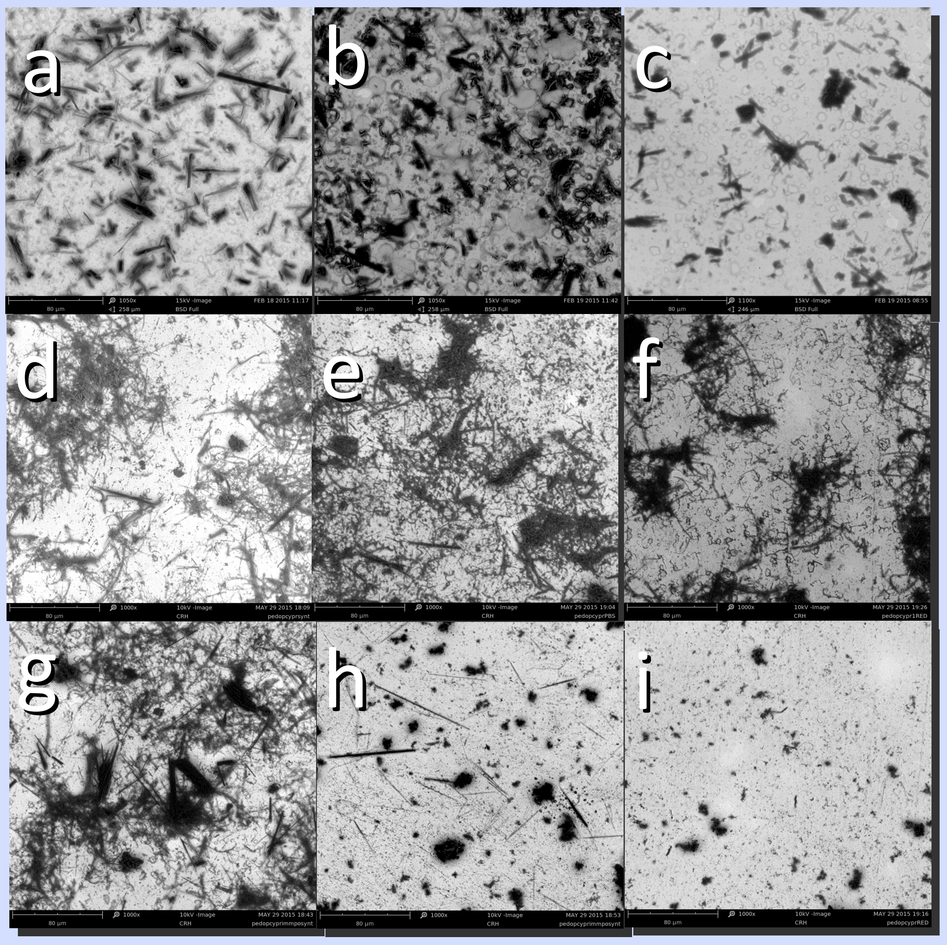

Figure 5 SEM images of matrices obtained via one step method (a-f) and three step method (g-i); PEDOP/Que films (a-c), PEDOP/Cipro films (d-i); films right after the immobilisation (a,d,g), after passive release (b,e,h) and after active release (c,f,i).

Conclusions

Both methods of drug immobilisation, one step and three step, have been successfully applied to obtain drug-modified polymer matrices. Depending on the immobilisation technique and model drug, there have been major differences in the dominant release modes. For PEDOP/Cipro films the dominant release modes is active release, while the passive release is dominant for PEDOP/Que films. SEM images show large variety of surface morphologies attainable by the proper choice of synthesis conditions.

Acknowledgements

This work was supported by National Science Centre in Poland (Preludium, NCN-2012/07/N/ST5/01878).