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Probing the Impact of Porosity on Swelling Kinetics of Hydrophilic Matrices

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SUMMARY

The aim of the present investigation was to understand the swelling behaviour of HPMC and PEO-based matrices and to evaluate the impact of porosity on the swelling kinetics. It was noticed that the HPMC has higher swelling rates but both undergo diffusion oriented swelling mechanism. It could also the concluded that the porosity has a marked influence in the development of gel layer on the surface of these matrices.

INTRODUCTION

Controlled release dosage forms are developed to sustain the delivery of the embedded drug for an extended period once administered. This phenomenon is usually ensured by using certain hydrophilic polymers, for example, hypromellose (hydroxypropyl methylcellulose, HPMC) or polyethylene oxide (PEO) in which the drug is homogenously dispersed. There are various types of controlled release formulations, however, compressed hydrophilic matrices (CHM) are most frequently used controlled release oral dosage forms (Maderuelo et al., 2011). Generally, CHM can be easily prepared by directly compressing the powder mixture of drug containing a swellable hydrophilic polymer and other additives to aid the process (Ghori & Conway 2016). These CHM have the ability to release the drug over a defined period of time, as they do not undergo disintegration when delivered to patients. Instead, they swell and develop a gel layer on the surface of the tablet which controls the liquid ingression as well as the diffusion of the drug. Swelling is considered to be a fundamental characteristic for success and unsatisfactory swelling may lead to formulation failure. The liquid imbibition into these CHMs is strongly affected by the tablet porosity. Commonly, a higher overall porosity leads to rapid penetration of liquid molecules in comparison to lower overall porosity thus impacting on the swelling behaviour (Ghori et al., 2017). Therefore, the objective of present study was to investigate the impact of porosity on the swelling kinetics of HPMC and PEO matrices.

MATERIALS AND METHODS

Hypromellose (HPMC, K4M) and polyethylene oxide (Polyox, NF60K) were obtained as a kind gift from Colorcon®, Dartford, UK.

HPMC and Polyox samples (500 ± 2.5 mg, 150-250 µm) were compressed using a Testometric M500–50 CT

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(Testometric Company Ltd., UK) equipped with a 13.00 mm Atlas Evacuable Tablet Die (Specac® Limited, UK). The compacts were fabricated at an applied pressure of 150 MPa. After ejection, the tablets were stored over silica gel for 24 h to allow for elastic recovery before any further investigations. The out-of-die porosity (ε) was calculated using Eq. 1. (Ghori et al., 2014a, 2017).

$$\varepsilon = 1 - \frac{W}{\rho(d/2)^2 \pi T} \qquad \text{(Eq. 1)}$$

where W, T, D, ρ are weight, thickness diameter and true density, respectively. The swelling studies were carried out for all the matrices using the gravimetrical technique as reported in our previous studies (Ghori et al., 2014a; 2014b). The mean weight was determined for each matrix tablet and degree of swelling (S) was calculated using Eq. (2). The mechanism of swelling was evaluated using employing the Vergnaud model (Vergnaud 1993).

$$S = \frac{Ws - Wi}{Wi} \times 100 \qquad \text{(Eq. 2)}$$

where Wi and Ws are initial dry and swollen matrix tablet weight, respectively, at immersion time (t).

RESULTS AND DISCUSSION

Swelling is considered as an essential aspect of controlling drug release from hydrophilic matrix devices. The swelling study was conducted on the matrices, on immersion in liquid the outer surface of these polymeric devices and a response was plotted (Fig 1a) against time (t). The tactical and visual inspection confirmed the appearance of so-called gel layer formation. It was apparent the HPMC matrices exhibited a higher extent of swelling in comparison to PEO (Fig 1a). The Vergnaud model was employed to further understand the swelling mechanism (Fig 1b). The swelling kinetics parameters, enlisted in Table 1, were well described by this model with high R^2 values of 0.99. The swelling rate of HPMC based matrices (51.14 % min^{-1}) was higher than PEO matrices (39.32 % min^{-1}). Additionally, based on the resultant swelling exponent (n) values (Table 1), both the polymer matrices exhibited diffusion controlled swelling being slightly higher in HPMC compared to PEO. It was interesting to note that this correlates well with the porosity. The correlation between porosity and swelling rate revealed that, in case of HPMC, porosity was lower while the Kw was higher. This might be attributed to the higher osmotic stress within the compact. However, a higher overall porosity (in case of PEO) the might lead to less matrix tortuosity impacting water capturing capacity (Ghori et al., 2017).

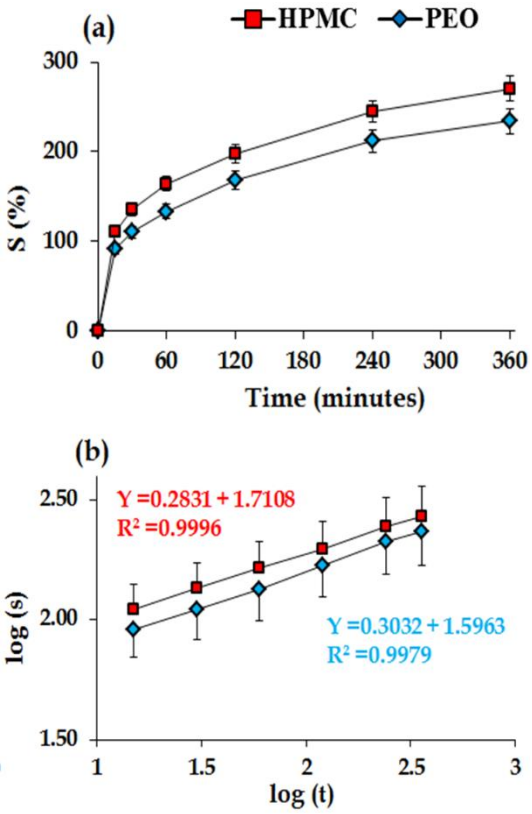

Figure 1. *Matrix tablet porosity and swelling kinetics parameters.*

Table 2. *Matrix tablet porosity and swelling kinetics parameters.*

Parameter	HPMC	PEO
Swelling rate (Kw)[a]	51.14	39.32
Swelling exponent (n)	0.2831	0.3032
R^2	0.9996	0.9979
ε[b]	0.1607	0.2170

[a] % min^{-1} and [b] porosity (%)

CONCLUSIONS

It can be concluded that the HPMC had a higher swelling rate in comparison to PEO, under the conditions in this study. Moreover, it could also the concluded that from the above research finding that the porosity has a marked influence on the overall swelling behaviour of the polymer matrices. Therefore, the present findings can be used in the development and tailoring the specific properties of controlled release solid dosage forms.

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