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Research paper

Optimised process and formulation conditions for extended release dry polymer powder-coated pellets

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ABSTRACT

The objective of this study was to improve the film formation and permeability characteristics of extended release ethylcellulose coatings prepared by dry polymer powder coating for the release of drugs of varying solubility. Ethylcellulose (7 and 10 cp viscosity grades) and Eudragit® RS were used for dry powder coating of pellets in a fluidised bed ball coater. Pre-plasticised ethylcellulose powder was prepared by spray-drying aqueous ethylcellulose dispersions (Surelease® and Aquacoat®) or by hot melt extrusion/cryogenic grinding of plasticised ethylcellulose. Chlorpheniramine maleate and theophylline were used as model drugs of different solubilities. The film formation process, polymeric films and coated pellets were characterised by differential scanning calorimetry (DSC), dynamic mechanical analysis (DMA), scanning electron microscopy (SEM) and dissolution testing. Film formation and extended drug release was achieved with ethylcellulose, a polymer with a high glass transition temperature (T_g) without the use of water, which is usually required in dry powder coating. DMA-measurements revealed that plasticised ethylcellulose had a modulus of elasticity (E') similar to the low T_g Eudragit® RS. With increasing plasticiser concentration, the T_g of ethylcellulose was reduced and the mechanical properties improved, thus facilitating coalescence of the polymer particles. SEM-pictures revealed the formation of a dense, homogeneous film. The lower viscosity grade ethylcellulose (7 cp) resulted in better film formation than the higher viscosity grade (10 cp) and required less stringent curing conditions. Successful extended release ethylcellulose coatings were also obtained by coating with pre-plasticised spray-dried ethylcellulose powders as an alternative to the separate application of pure ethylcellulose powder and plasticiser. The permeability of the extended release coating could be controlled by using powder blends of ethylcellulose with the hydrophilic polymer HPMC. In conclusion, dry polymer powder coating is an interesting technique to achieve extended release of drugs with varying solubility as an alternative to classical coatings obtained from organic polymer solution or aqueous polymer dispersions.

1. Introduction

Extended release polymers are usually coated onto solid dosage forms from either organic polymer solutions or aqueous polymer dispersions. However, there are various disadvantages with these liquid coating formulations. Organic coating systems pose environmental and toxicological concerns. The aqueous systems require high temperature and prolonged processing times resulting in high energy consumption due to the evaporation of water and to reach temperatures above the minimum film formation temperature (MFT) [1,2]. Moreover, films from aqueous dispersions often suffer stability problems due to aging phenomena. Dry powder coating is an innovative method for the coating of solid dosage forms without the use of organic solvents and limited amount of water with a very short processing time. The polymer is applied as a micronised powder directly onto the dosage form with or without the simultaneous spraying of a liquid plasticiser [3–8].

The most important aspect giving reason to criticism on dry powder coating was the use of water or aqueous binder solutions [7,8]. These small amounts were introduced to facilitate the adhesion of the polymer particles onto the substrate surface and to induce their coalescence [3–5]. Heating alone was not sufficient to achieve film formation, especially for polymers with high glass transition temperature, such as hydroxypropyl methyl cellulose acetate succinate (HPMCAS) or ethylcellulose.

Uncured pellets coated by dry powder coating resulted in porous, inhomogeneous films with fast drug release. The formation of a homogeneous, dense film was difficult to achieve [5,6]. However, a porous film is not able to effectively retard the release of a freely soluble drug. Neither extended release nor gastric resistance or taste masking could be achieved even for drugs of low or moderate solubility (e.g. theophylline and propranolol HCl)

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without a thermal after-treatment (curing) at elevated temperatures [4–7]. Coalescence and the formation of a dense, continuous film were only achieved after curing [5,9,10].

The mechanics of film formation of polymer particles in the dry state relies on viscous flow [11–14]. Plastic deformation and coalescence are facilitated with decreasing elastic modulus and viscosity of the polymer [15]. The viscosity of the polymer will be reduced by plasticisers or at elevated temperature [11]. Thus, the described process conditions were not appropriate to achieve coalescence during the coating process without a curing step.

Ethylcellulose films often result in very impermeable coatings. Water-soluble additives such as hydrophilic polymers or sugars are often incorporated as pore-formers to modify the release. During drug release, these additives swell or leach rendering the coating more permeable and result in an enhanced drug release [1,16,17].

The objectives of the present studies were to improve the film formation during dry powder coating, such that film formation can be achieved during the coating process without the additional use of water or thermal impact. Moreover, a specific objective was to challenge the system to achieve extended drug release for model drugs of higher solubility at coating levels comparable to conventional coating systems. Different polymer systems (Eudragit RS®, Ethylcellulose of different viscosities) and process conditions were investigated as well as the effect of HPMC as a water soluble pore former to modify the drug release rate from polymer powder-coated pellets.

2. Materials and methods

2.1. Materials

Chlorpheniramine maleate (CPM) (STADA Arzneimittel AG, Bad Vilbel, Germany), theophylline pellets (unretarded, 94% drug content, Klinge Pharma GmbH, München, Germany), ethylcellulose (EC) (Ethocel Standard premium 10 FP and 7 FP, DOW Chemical Company, Midland, USA), ammonio methacrylate copolymer type B (Eudragit® RS) (Röhm GmbH&Co. KG, Darmstadt, Germany), hydroxypropyl methylcellulose (HPMC) (Methocel E5, Colorcon Ltd., Kent, UK), unplasticised aqueous dispersion of ethylcellulose (Aquacoat® ECD, FMC BioPolymer, Newark, USA), aqueous dispersion of ethylcellulose plasticised with medium chain triglycerides (MCT) (Surelease®, Colorcon Ltd., Kent, UK), acetylated monoglycerides (AMG) (Myvacet 9-45, Quest International, Zwijndrecht, Netherlands), tributyl citrate (TBC) (Morflex Inc., Greensboro, USA), medium chain triglycerides (MCT) (Miglyol 812, Sasol GmbH, Witten, Germany), talc (Luzenac Val Chisone S.p.A., Pinerolo, Italy), nonpareil beads (NP Pharma S.A.S., Bazainville, France), colloidal silicium dioxide (Aerosil® 200, Degussa, Hanau, Germany).

2.2. Methods

2.2.1. Micronised polymer powders for coating

Ethylcellulose is commercially available as a fine powder in the lower μm-size range (5–15 μm) [18], whereas Eudragit® RS was milled to a mean particle size of 9.4 μm (Axiva GmbH, Franfurt, Germany) [4]. HPMC was cryogenically milled on a high-speed rotor mill under cooling with liquid nitrogen in two steps with sieve inserts of 0.75 mm and 0.12 mm grain size at a rotor speed of 10,000 rpm (Rotor Speed Mill Pulverisette 14, Fritsch GmbH, Idar-Oberstein, Germany).

2.2.2. Preparation of plasticised ethylcellulose powder

Ethylcellulose is commercially available as a fine powder in the lower μm-size range (5–15 μm) [18]. Plasticised ethylcellulose was obtained by mixing the standard ethylcellulose powder with the plasticiser MCT (20% w/w, based on polymer) in a planetary mixer (Kitchen Aid Ultra Power, Michigan, USA; speed position: 8) for 30 min. The mixture was then hot melt extruded (HME) at 140 °C (Haake Minilab, Thermo Electron GmbH, Karlsruhe, Germany; co-rotating twin screws, torque: 20 ± 5 N cm, screw speed: 30 rpm, force feeder speed: 50 rpm, die: 1 mm diameter). The extrudate was cut into pieces of 2–3 cm and cryogenically milled on a high-speed rotor mill under cooling with liquid nitrogen in two steps with sieve inserts of 0.75 mm and 0.12 mm grain size at a rotor speed of 10,000 rpm (Rotor Speed Mill Pulverisette 14, Fritsch GmbH, Idar-Oberstein, Germany).

2.2.3. Spray-drying of aqueous ethylcellulose dispersions

Aquacoat® (containing 20% w/w MCT based on polymer; plasticisation: 24-h stirring at ambient condition on a magnetic stirrer (IKA Combimag RCT; Jahnke&Kunkel GmbH, Staufen, Germany)) or Surelease® were diluted 1:1 with deionised water and spray-dried on a lab-scale spray-dryer (Büchi 190 Mini Spray Dryer, Laboratoriumstechnik AG, Flowil, Switzerland) at the following conditions: inlet air: 105 ± 3 °C, outlet air: 59 ± 2 °C, atomizing pressure: 19 mbar, flow indicator: 600 norm l/h, aspirator positioning: 6, spray rate: 4.5 g/min.

2.2.4. Drug layering

Ninety gram of chlorpheniramine maleate (CPM) and 0.42 g PEG 400 were dissolved in 168.75 g (96% v/v) ethanol and 112.5 g water. Thereafter, 42.2 g of an aqueous 10% w/w HPMC solution was added. Drug-loaded pellets (10% w/w, drug loading) were prepared by layering the drug-binder solution onto 900 g nonpareil beads (710–850 μm) using a fluidised bed coater (Hüttlin® ball coater, Unilab 05, Steinen, Germany). The drug-layering conditions were: inlet air temperature, 50 °C; product temperatures, 42–45 °C; spray rate, 4–5 g/min; atomizing air pressure, 0.2/0.4 bar; spray nozzle diameter, 0.8 mm.

2.2.5. Dry powder coating of drug-loaded pellets

Drug-loaded pellets were dry powder coated in a fluidised bed ball coater (Hüttlin® ball coater, Unilab 05, Steinen, Germany) This coater has two nozzles. One was used to introduce the micronised polymer powder by a volumetric helix dosing feeder (Secudos, G + K Fuchs GmbH, Wiehl, Germany). The plasticiser was supplied by a peristaltic pump (Modell 323S/D/X, Watson + Marlow GmbH, Rommerskirchen, Germany) and sprayed simultaneously through the second (nozzle size: 0.6 mm). The liquid plasticiser (1% w/w based on the pellet batch size) was sprayed to wet the pellets prior to starting the feeding of the polymer powder. For the coating with Eudragit® RS, the polymer was used in a 1:1 mixture with talc to prevent agglomeration and sticking of the pellets during coating. The process conditions for all coating systems are summarised in Table 1. The atomizing air pressure was 0.2/0.4 bar in all cases. The mean particle size of the polymer powder was 6.1 μm for ethylcellulose 10 cp, 9.7 μm for ethylcellulose 7 cp and 9.4 μm for Eudragit RS. When water was additionally used, it was sprayed at the end of the coating process without further plasticiser or other additives. The pellets were cured after coating at the indicated conditions. Prior to curing, 0.5% colloidal silicium dioxide (Aerosil® 200) was added to the pellets to prevent sticking during curing.

2.2.6. Drug release

Drug release was determined according to Ph.Eur. in a paddle apparatus (VK700, Vankel Industries, Edison, NJ, USA) in 900 ml phosphate buffer pH 6.8 (Ph.Eur.) at 37 °C and 100 rpm ($n = 3$). Samples were taken at predetermined time points, and the drug content was quantified spectrophotometrically (UV-2101 PC, Shi-

Table 1
Process parameters and particle sizes of micronised polymer powders used for dry powder coating.

Parameter	System			
	EC 10 cp	EC 7 cp	Pre-plasticised Ethylcellulose[a]	Eudragit® RS
Inlet air temperature, °C	50 ± 1	50 ± 1	42 ± 2	42 ± 2
Outlet air temperature, °C	51 ± 1	51 ± 2	47 ± 1	45 ± 2
Product air temperature, °C	44 ± 1	44 ± 2	36 ± 2	38 ± 4
Powder feeding rate, g/min	10	10	12	10
Plasticiser feeding rate, g/min	5	5	3	5

[a] From Aquacoat® or Surelease® or powder prepared by hot melt extrusion (HME).

madzu Scientific Instruments, Columbia, MD, USA) at λ_{max} for chlorpheniramine maleate at 261 nm and for theophylline at 270 nm.

2.2.7. Dynamic mechanical analysis (DMA)

Unplasticised and plasticised ethylcellulose films with 20% w/w plasticiser (based on the formulation) and unplasticised Eudragit® RS films were cast from 10% w/w chloroform solutions (10 ml) at 1-mm thickness with a casting knife (Multicator 411, Erichsen, Hemer, Germany) and dried on Teflon® plates at room conditions. The thickness of the films was 100–150 μm (Minitest 600, Erichsen, Hemer, Germany; $n = 10$). DMA-measurements were performed by the application of a sinusoidal force resulting in a small deformation of 10 μm at a frequency of 3.3 Hz (DMA 242C, Netzsch Gerätebau GmbH, Selb, Germany). The amplitude of the deformation, the force and the phase shift were measured on ethylcellulose films by the use of tension clamps in the range of 0–150 °C. The measurement parameters enabled the calculation of the storage and loss modulus as a function of temperature.

2.2.8. Differential scanning calorimetry (DSC)

Plasticised ethylcellulose films containing 10, 20 or 40% w/w plasticiser (based on the formulation) were prepared as described earlier. DSC measurements were performed on samples of 5–10 mg in the range of −100 to 200 °C at a heating rate of 10 °C/min (Mettler Toledo DSC 821[e], Schwerzenbach, Switzerland; calibration with indium and zink, N_2-atmosphere: 80 l/min) ($n = 2$). The glass transition temperature (T_g) was evaluated with the Star[e]-software version 6.01 (Mettler Toledo, Schwerzenbach, Switzerland).

2.2.9. Optical and (environmental) scanning electron microscopy

The particle size of the micronised ethylcellulose and HPMC powders was measured by an optical microscope (magnification: 20×; Axioscop, Carl Zeiss Jena GmbH, Jena, Germany; $n = 200$). The mean particle size and standard deviation was calculated.

Coated pellets were examined either by environmental scanning electron microscopy or under vacuum by scanning electron microscopy.

Environmental scanning electron microscopy (ESEM) was performed without further conditioning or coating (ESEM, FEI XL30, Eindhoven, The Netherlands). A partial water vapour pressure between 0.2 and 0.8 mbar was applied to prevent the samples from charging during electron exposure. Imaging was performed using acceleration voltages between 4 and 16 kV.

Scanning electron microscopy (SEM) was performed after coating the pellets for 230 s with gold–palladium (SCD 040, Bal-Tec GmbH, Witten, Germany) under an argon atmosphere. The surface morphology of the pellets was examined using secondary electron imaging at 10 kV (S-4000, Hitachi High-Technologies Europe GmbH, Krefeld, Germany).

3. Results and discussion

Film formation from polymer particles during polymer powder coating works well with polymers with a low T_g [6,7,9,19]. It is more critical with polymers with a high T_g [10], for example with ethylcellulose (T_g = 133 °C), which is a widely used extended release polymer. Formulation and process parameters have to be optimised in order to improve particle coalescence during dry powder coating.

In this study, extended release from polymer-coated pellets was achieved not only with polymers of low T_g like Eudragit® RS (T_g = 58 °C) but also for ethylcellulose, even without the use of additional water (Fig. 1). The additional spraying of water, commonly used for further film coalescence [3], did not affect the drug release significantly (Fig. 1). It is essential, that the applied temperature, either during coating or curing, is above the T_g of the polymer to induce the viscous flow of the particles for coalescence. In general, a temperature of 10–50 °C above the T_g is necessary [4–8].

The results were supported by DMA-measurements. The modulus of elasticity (E') of unplasticised Eudragit® RS films is lower than that of ethylcellulose films (24.1 vs. 6.4 MPa) (Fig. 2). How-

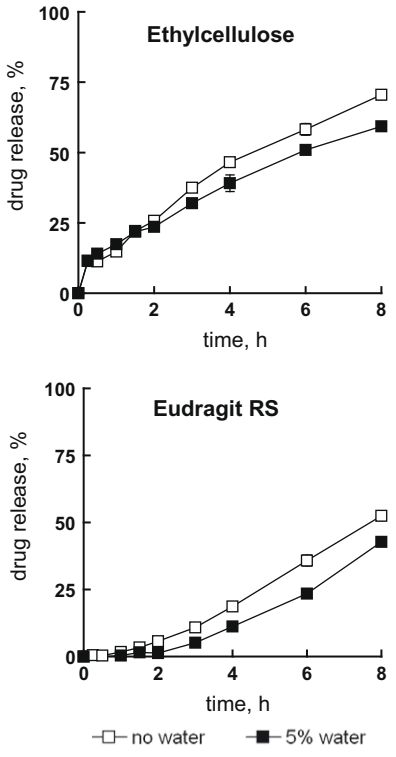

Fig. 1. Effect of water on chlorpheniramine maleate release from dry powder-coated pellets (coating level: 15%; curing: ethylcellulose: 80 °C/24 h, Eudragit® RS: 60 °C/2 h).

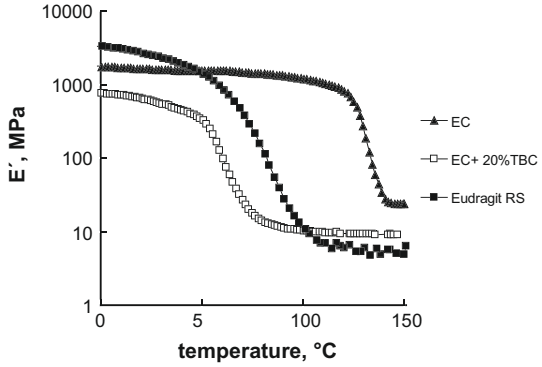

Fig. 2. Modulus of elasticity (E') of ethylcellulose (EC) films with or without 20% w/w tributyl citrate (TBC) and Eudragit® RS films (film thickness: 100–150 μm).

ever, ethylcellulose plasticised with 20% w/w TBC had a comparable modulus of elasticity as pure Eudragit® RS above the T_g in the rubbery state (9.1 vs. 6.4 MPa) (Fig. 2). Thus, ethylcellulose, a hard and brittle polymer, can acquire similar mechanical behaviour for film formation as Eudragit® RS, a soft and flexible polymer, with the appropriate type and amount of plasticiser.

The coalescence and film formation of dry powder coatings was confirmed by ESEM-pictures. A dense, continuous film was formed (Fig. 3A). Single, uncoalesced particles were not visible anymore throughout the film (Fig. 3B). However, due to the random deposition of the polymer particles on the surface of the dosage form, imperfections may occur, which can result in a varying thickness of the film (Fig. 3B).

A coating level of 10% assured extended drug release of theophylline, a slightly soluble model drug (solubility in pH 7.4: 12.0 mg/ml [20]), while for chlorpheniramine maleate, a freely soluble model drug (solubility in pH 7.4: 562 mg/ml [21]), 15% was required to achieve a similar release profile (Fig. 4). Chlorpheniramine maleate was released with an initial burst, which was reduced to ~12.5% at a coating level of 15% and was followed by a zero-order release kinetic. In conclusion, extended release can be achieved for both slightly and freely water-soluble drugs at coating levels between 10% and 15%. With an optimal plasticiser, such as TBC, curing was not required. It had only a minor effect on the drug release (data not shown).

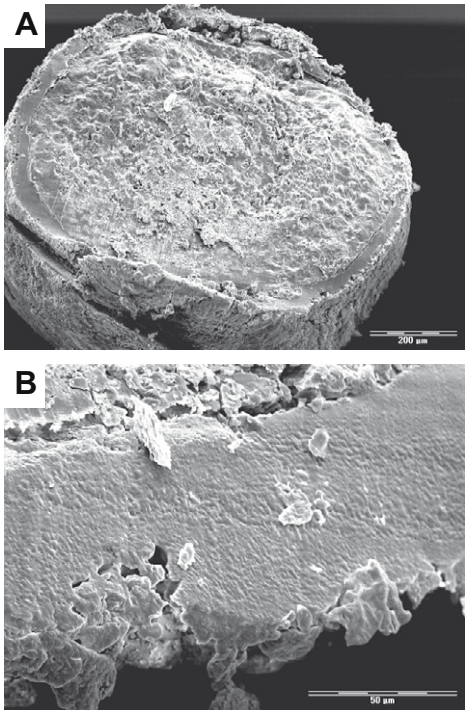

Fig. 3. ESEM-pictures of ethylcellulose powder-coated pellets: (A) cross section, (B) magnification of the coat (coating level: 15%, plasticiser: 50% w/w TBC based on polymer; no curing).

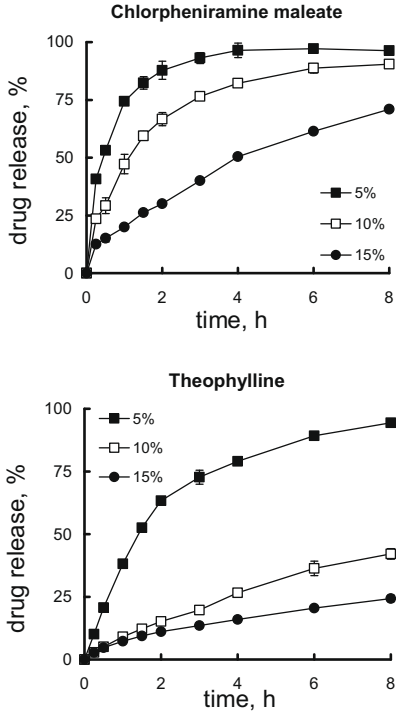

Fig. 4. Effect of coating level and type of drug on the drug release from ethylcellulose powder-coated pellets (plasticiser: 50% w/w TBC w/w based on polymer; curing: 80 °C/24 h).

Besides the plasticiser, the extent of film formation is strongly influenced by polymer properties, such as its viscosity and particle size [11,12]. The viscosity of the polymer, which can be reduced by plasticisers or elevated temperature, is also dependent on the molecular weight of the polymer. Higher molecular weight polymers generally result in tougher films with higher yield strength and lower permeability [22]. However, a higher molecular weight polymer could also impede the film formation from polymer particles because of a higher viscosity. The use of a lower viscosity grade ethylcellulose powder (7 cp) remarkably improved the film formation and thus reduced the drug release when compared to the higher viscosity grade ethylcellulose (10 cp) with acetylated monoglycerides as plasticiser, when cured above the T_g (Fig. 5). At 80 °C, the limiting release profile was obtained independent of the polymer viscosity, as both polymers were above their T_g. No differences between the two ethylcellulose grades were seen, when a plasticiser with optimal performance such as tributyl citrate was used. Tributyl citrate resulted in extended drug release already with the uncured pellets, as the polymer is already below its T_g. Curing, even at 80 °C, did not decrease the drug release more than 15% compared to the uncured pellets, confirming the very good initial film formation during the coating process.

Alternatively to the addition of the plasticiser during the coating process, the approach of using pre-plasticised ethylcellulose was investigated. A better film formation at lower coating temperatures was expected with these pre-plasticised particles [10]. Pre-plasticised ethylcellulose powders were prepared by either hot melt extrusion/cryogenic grinding (HME ethylcellulose) or by

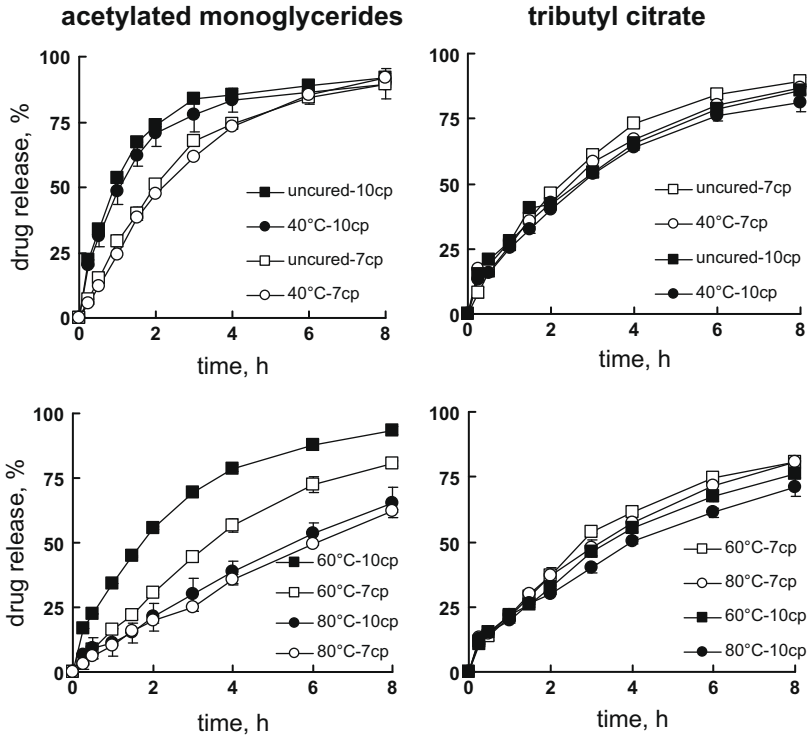

Fig. 5. Effect of viscosity grade of ethylcellulose (7 and 10 cp) on the chlorpheniramine maleate release from uncured and cured ethylcellulose powder-coated pellets (plasticiser: 50% w/w based on the polymer; curing time: 24 h).

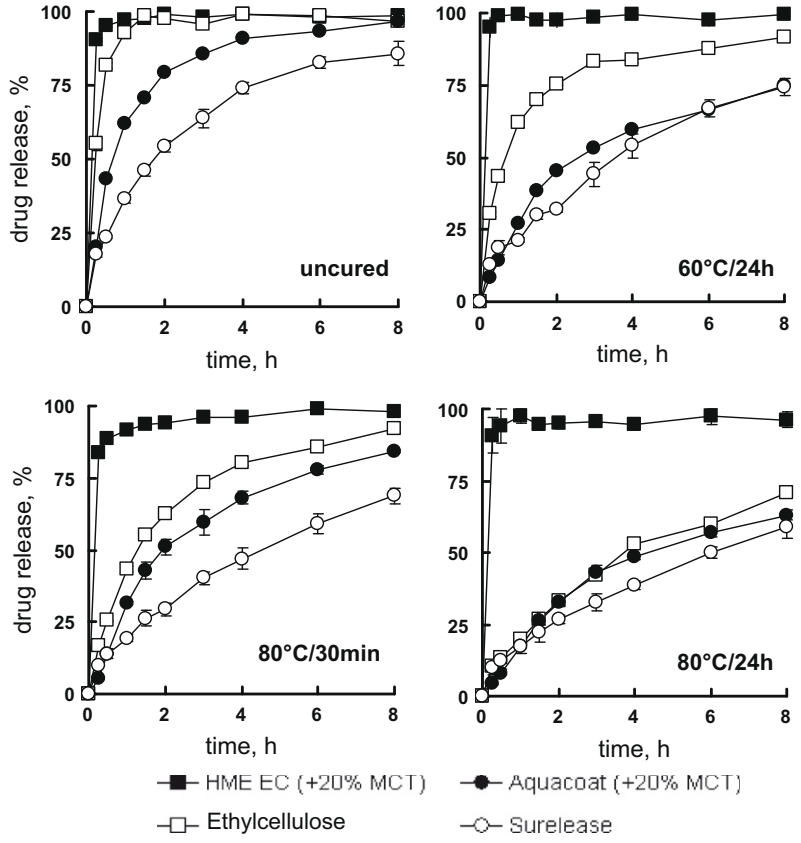

Fig. 6. Effect of pre-plasticisation of ethylcellulose and curing conditions on the chlorpheniramine maleate release from ethylcellulose powder-coated pellets (coating level: 15%).

spray-drying two commercially available plasticised aqueous colloidal ethylcellulose dispersions (pseudolatexes). Surelease® is a pre-plasticised aqueous ethylcellulose dispersion containing approx. 20% w/w medium chain triglycerides (MCT) based on polymer. In contrast, Aquacoat® is an unplasticised aqueous ethylcellulose dispersion and was therefore plasticised with 20% w/w MCT before spray-drying. The T_g of ethylcellulose was reduced by pre-plasticisation to approx. 50 °C. A better film forma-

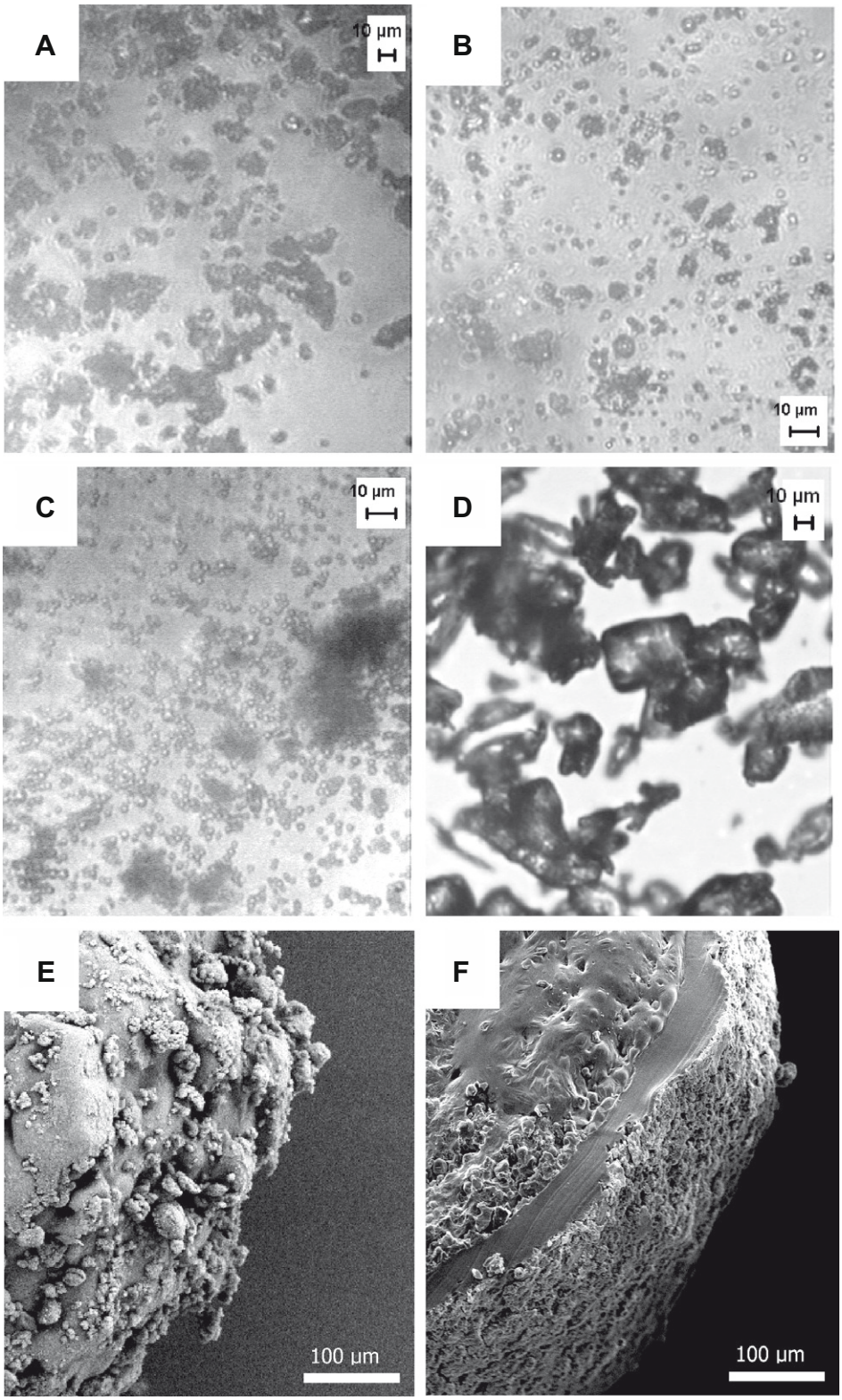

Fig. 7. Optical microscopic pictures of (A) micronised pure ethylcellulose, (B) spray-dried Surelease powder, (C) spray-dried Aquacoat powder containing 20% w/w MCT, (D) hot melt extruded/cryogenically ground ethylcellulose (+20% w/w MCT), ESEM-pictures of (E) pellets coated with hot melt extruded/cryogenically ground ethylcellulose and (F) pellets with micronised ethylcellulose.

tion, as reflected by a decrease in drug release, was achieved for the pre-plasticised ethylcellulose powders obtained by spray-drying (Fig. 6), whereas no film formation and thus no retardation of the drug release could be achieved with the hot melt extruded powder. Even after curing up to 80 °C for 24 h, no retardation of the drug release occurred. The lack in film formation was attributed to the larger particle size of the hot melt extruded ethylcellulose powder. Spray-drying of aqueous ethylcellulose dispersions, either of the pre-plasticised Surelease® or of Aquacoat® after plasticisation, resulted in a fine powder of a particle size comparable to pure ethylcellulose powder, whereas the powder obtained after hot melt extrusion/cryogenic grinding had a considerably larger particle size (mean particle size: ethylcellulose powder: 2.8 μm, Surelease®: 3.1 μm, Aquacoat®: 2.0 μm, HME powder: 27.3 μm) (Fig. 7). As the film formation from polymer particles is strongly influenced by the particle size, the deformation of the particles above a certain size may be insufficient to achieve coalescence [11,12]. SEM-pictures confirmed the differences in particle size of the different ethylcellulose powders (Fig. 7A–D). Pellets coated with ethylcellulose powder obtained by hot melt extrusion/cryogenic grinding (Fig. 7E) exhibited a rough surface with distinct polymer particles, indicating that no film formation occurred [9,10]. In contrast, the surface of the pellets coated with micronised ethylcellulose with simultaneous spraying of the plasticiser displayed a much smoother appearance with no individual polymer particles on the surface (Fig. 7F). The appearance of pellets coated with the spray-dried polymer powders of Aquacoat® and Surelease® was comparable (data not shown).

Pure ethylcellulose often results in rather impermeable coatings and thus a too slow release, especially for drugs of low solubility. Water-soluble polymers such as HPMC are often added as pore-formers to enhance the drug release through ethylcellulose coatings [1,16,17]. With aqueous polymer dispersions, HPMC may induce flocculation of the dispersion [16,23]. Moreover, the viscosity of the system may increase to a magnitude at which spraying gets difficult. Dry powder coating avoids these problems

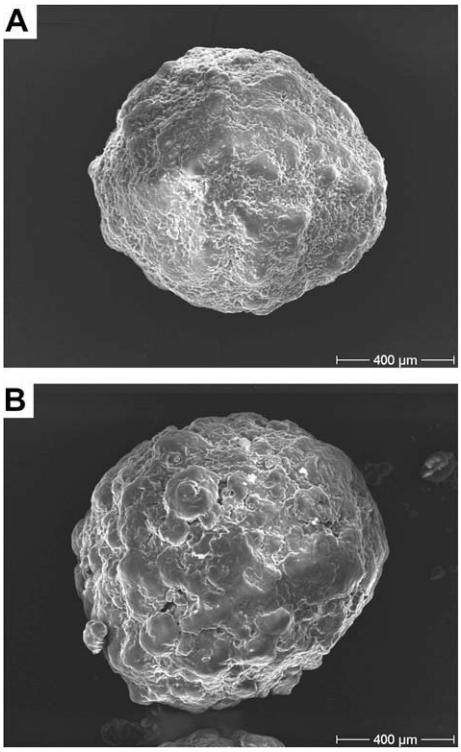

Fig. 9. SEM-pictures of ethylcellulose: HPMC powder-coated pellets: (A) ethylcellulose:HPMC (4:1), (B) ethylcellulose:HPMC (2:1) (coating level: 15%, plasticiser: 50% TBC w/w based on total polymer; no curing).

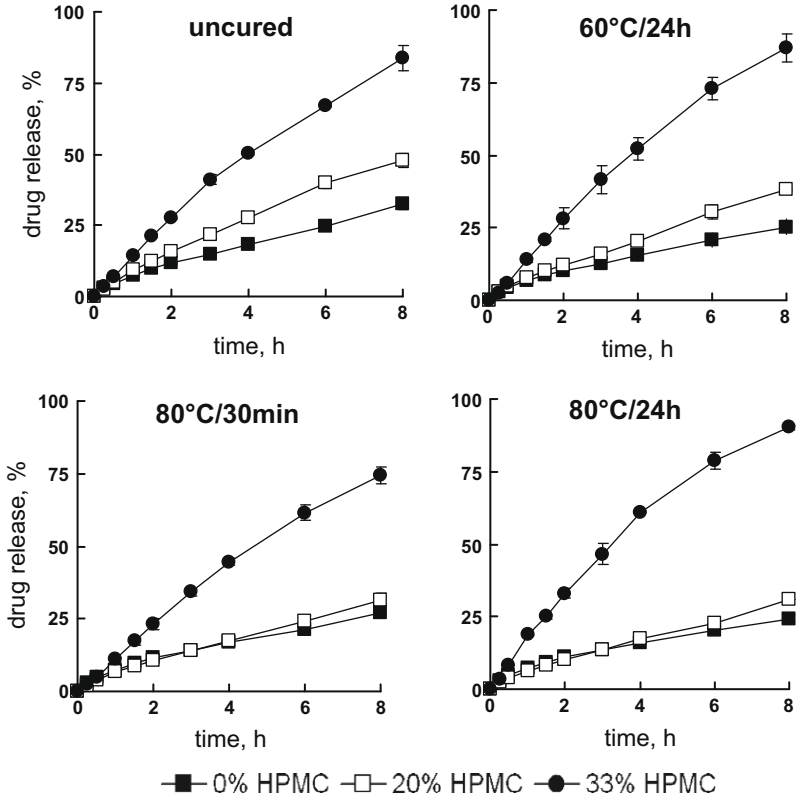

Fig. 8. Influence of HPMC on the theophylline release from ethylcellulose: HPMC powder-coated pellets (coating level: 15%, plasticiser: 50% TBC w/w based on total polymer).

observed with aqueous polymer dispersions, as both polymers are in the dry state during the coating process. The addition of micronised HPMC to ethylcellulose (EC:HPMC, 4:1) increased the drug release of theophylline only slightly for uncured pellets and those cured at 60 °C for 24 h (Fig. 8). This confirmed a still excellent film formation in spite of the slightly larger particle size of the HPMC powder compared to pure ethylcellulose (13.3 μm vs. 2.8 μm) (Fig. 9). Pellets cured at 80 °C for only 30 min already resulted in the same release profile as pure ethylcellulose-coated pellets. A further increase in HPMC amount (EC:HPMC, 2:1) resulted in an increase in drug release, which did not decrease upon curing. SEM-pictures revealed the formation of a more inhomogeneous film with a much rougher surface compared to only 20% HPMC in the mixture (Fig. 9). A considerable increase in the permeability of ethylcellulose films occurs only above a certain critical concentration of about 24% HPMC in the coating [24,25]. Below this critical concentration, the leaching of the large HPMC-molecules is insufficient to build pores, and thus no effect can be observed during the drug release. In summary, the drug release from ethylcellulose powder-coated pellets could be controlled by the addition of the hydrophilic polymer HPMC.

4. Conclusions

Film formation and extended release can be achieved by dry powder coating without the use of additional water. Increasing plasticiser concentration reduced the T_g of ethylcellulose and improved the mechanical properties of the films. SEM-pictures confirmed the formation of a dense, homogeneous film. Extended drug release was achieved for drugs of different solubility (slightly to freely soluble). Pre-plasticisation of the polymer is an effective method to further improve film formation and to achieve extended drug release. The drug release could also be modified by including hydrophilic HPMC powder in the ethylcellulose coating. Dry polymer powder coating uses the same equipment and excipients as classical coatings and is thus an interesting alternative to liquid coatings.

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