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Short Communication

Comparative investigations on different polymers for the preparation of fast-dissolving oral films

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Abstract

Objectives The aim was to compare different film-forming materials used for the preparation of fast-dissolving oral films.

Methods Films were prepared with and without caffeine and caffeine citrate as model drugs. The disintegration/dissolution behaviour of films was investigated using the newly developed slide frame method and Petri dish method. Films were also characterised by dynamic vapour sorption.

Key findings All films dissolved within 40 s. Drug-loaded films disintegrated more slowly than the equivalent drug-free formulations. Disintegration/dissolution was fastest with films made from the carboxymethyl cellulose C 30 PA 09 (drug-free < 5 s, drug-loaded < 10 s). Dissolution times for drug-loaded oral films made from C 30 PA 09 and HM 6 PA 2910 (hydroxypropyl methyl cellulose) differed significantly ($\alpha = 0.05$). Dynamic vapour sorption studies revealed higher water absorption ratios for carboxymethyl cellulose films, and these were sticky and difficult to handle.

Conclusions This case study showed that hydroxypropyl methyl cellulose was the most suitable film-forming material for drug-free and caffeine-loaded films, providing fast dissolution films that were not sticky and were easy to handle.

Keywords fast-dissolving dosage form; film formers; film thickness; hypromellose; oral films

Introduction

Fast-dissolving oral films are novel dosage forms which are particularly suitable for paediatric and geriatric use. No additional water is needed for drug administration because the films dissolve in saliva after application.[1] Ease of handling and convenient dosing also improve patient compliance.[2] Oral films have been investigated over the last years but a systematic study of fast-dissolving film formers has not been performed. Many different polymers for use in oral films are proposed in patent literature,[3] and various research groups have introduced different materials.[4] Cellulose ethers are widely available and economical. Pullulan, an α-1,6-linked maltotriose produced from the fungus *Aureobasidium pullulans*, has also been used.[5] Starches and maltodextrin have also been investigated as alternative film formers.[6–8]

Several papers have investigated the use of one polymer or a special polymer blend for preparation of fast-dissolving oral films,[9–11] and others have evaluated the influence of polymer ratio on film properties.[12–15] Other papers describe the use of several polymers but were limited to the application as mucoadhesive polymers and did not have the aim of fast-dissolving behaviour.[16–19] In summary, various approaches have been developed but a comparative study of polymeric film formers for use in fast-dissolving oral films is still not available.

Because the amount of saliva in the human oral cavity is limited, conventional disintegration[9,20] and dissolution[9,11,21,22] methods are not suitable. Another problem that has already been addressed in the literature is the poor uniformity of drug content in oral films.[23]

The aim of this study was a systematic comparison of different film formers under controlled conditions. Suitability of fast-dissolving oral films was evaluated in terms of disintegration/dissolution behaviour, film thickness and dynamic vapour sorption. Based on those results, the most suitable polymers were further processed to oral films loaded with

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caffeine or its highly water-soluble salt, caffeine citrate, as active pharmaceutical ingredient (API).

Materials and Methods

Materials

Different types of polymers were used as film formers: several types of sodium carboxymethyl cellulose (CMC), several types of hydroxypropyl methyl cellulose (HPMC), a synthetic copolymer of polyethylene glycol–polyvinyl alcohol (Kollicoat IR) and sodium alginate. Detailed information on the origin of excipients is given in Table 1. The different types of CMC (Walocel C 30 PA 09, C 2.000 PA 07, C 2.000 PA 09 and C 40.000 PA 09) differ in either the viscosity of a 2% aqueous solution (first index number) or in the degree of substitution (second index number). The different types of HPMC (HM 6 PA 2910, HM 50 PA 2910 and HM 4.000 PA 2910) differ only in terms of viscosity (first index number). Instacoat P-4 is a mixture of talc, titanium dioxide, triacetin and sodium alginate in which the alginate is the film-forming agent. Glycerol 85% and sorbitol were used as plasticisers to enable film casting. Tween 80 and Brij 35 were used as surfactants, and citric acid served as a saliva-stimulating agent. All substances were used as received and all solvents were of analytical grade.

Preparation of oral films

Based on patent information and scientific literature, a basic formulation was developed on the basis of main components[3,24] such as film former, plasticiser, saliva stimulant, surfactant (and API) (Table 2). Further potential excipients such as stabilisers, superdisintegrants, preservatives and mouthfeel improvers were not included. This basic formulation contained a solvent (water : alcohol 96%, 1 : 1), film-forming material in slightly varying amounts according to the gel-forming properties of the polymer, plasticisers such as glycerol 85% and sorbitol, surfactants (Tween 80 and Brij 35) and citric acid as a saliva-stimulating agent. The most successful formulations were used to produce drug-loaded oral films (Table 2). Film solutions were loaded with 2.0 g free base or 3.98 g caffeine citrate (see Table 2).

The oral films were prepared according to a standard procedure (Figure 1). The film solutions were cast on an Erichsen film applicator (Coatmaster 509/1, Erichsen, Hemer, Germany) with a speed of 6 mm/s. The thickness of the drug-free films differed between 300 and 400 μm (wet film thickness) depending on the peelability of the dried films from the release liner. The drug-loaded films made from different polymers were cast with the same thickness (500 μm, Table 3) to achieve equal drug loads of 10 mg caffeine per oral film (6 cm^2). The cast films were dried in an oven at 60°C for 2 h. Individual films were prepared by cutting the films into pieces of 2 × 3 cm.

Disintegration/dissolution

As there is no official dissolution test for drug-loaded oral films, we developed a simple disintegration/dissolution test with a few millilitres of medium to mimic the natural conditions in the oral cavity. A slide frame holding an oral film was laid on a Petri dish and one drop of distilled water added using a pipette; the time taken for the drop to dissolve the film and form a hole in it was recorded.

To compare the results, a second method was developed, in which 2 ml distilled water was placed in a Petri dish. One film was placed on the surface of the water and the time taken for the oral film to dissolve completely was measured. Measurements were performed five times for each formulation.

Film thickness

Film thickness was determined using a micrometer screw (Mitutoyo, Neuss, Germany). Each film was measured at five positions (central and the four corners) and the mean value calculated. The reduction of film thickness (as a %) was calculated as the quotient of wet- to dry film thickness: reduction of film thickness = $(1 - \text{film thickness}_{dry}/\text{film thickness}_{wet}) \times 100$. The measurement was performed 10 times.

Dynamic vapour sorption

The percentage increase in mass of films was measured using a moisture sorption test system (SPS11, Projekt Messtechnik, Ulm, Germany). The films were exposed to 98% relative

Table 1 Description of the materials used

Chemical substance	Product	Supplier
Carboxymethyl cellulose	Walocel C series	DowWolff Cellulosics, Bomlitz, Germany
Hydroxypropyl methyl cellulose	Walocel HM series	DowWolff Cellulosics, Bomlitz, Germany
	Metolose 65SH-1500	Syntapharm GmbH, Mülheim/Ruhr, Germany
	Pharmacoat 615	Shin Etsu Chemical Co., Ltd, Tokyo, Japan
Polyethylene glycol-polyvinyl alcohol copolymer	Kollicoat IR	BASF AG, Ludwigshafen, Germany
Sodium alginate	Instacoat P-4	Syntapharm GmbH, Mülheim/Ruhr, Germany
Glycerol 85%	glycerol 85%	Caesar & Loretz, Hilden, Germany
Sorbitol	Sorbidex P5	Cerestar, Krefeld, Germany
Polysorbate 80	Tween 80	Uniqema, Bromborough, UK
Dodecyl-poly(ethylene oxide-23) ether	Brij 35	Uniqema, Bromborough, UK
Citric acid	Citric acid	Dr Paul Lohmann GmbH KG, Emmerthal, Germany
Caffeine base	Anhydrous caffeine	Caesar & Loretz, Hilden, Germany
Caffeine citrate	Caffeine citrate	Caesar & Loretz, Hilden, Germany

Table 2 Composition of films

	Polymer	AC	CC	Sorbitol	Glycerol 85%	Citric acid	Tween 80	Brij 35	Alcohol 96%	Water
C 30 PA 09	4.57			2.28	0.91	0.46	0.08	0.30	45.70	45.70
C 30 PA 09 + CC	4.44		2.94	2.22	0.89	0.44	0.07	0.30	44.35	44.35
C 2.000 PA 07	4.57			2.28	0.91	0.46	0.08	0.30	45.70	45.70
C 2.000 PA 09	2.72			2.33	0.93	0.47	0.08	0.31	46.58	46.58
C 40.000 PA 09	1.96			2.35	0.94	0.47	0.08	0.31	46.95	46.95
HM 6 PA 2910	10.67			2.14	0.86	0.43	0.07	0.29	42.77	42.77
HM 6 PA 2910 + AC	10.54	1.41		2.11	0.83	0.42	0.07	0.28	42.17	42.17
HM 6 PA 2910 + CC	10.40		2.76	2.08	0.83	0.42	0.07	0.28	41.58	41.58
HM 50 PA 2910	4.91			2.28	0.91	0.46	0.08	0.30	45.53	45.53
HM 50 PA 2910 + AC	4.86	1.49		2.23	0.90	0.45	0.07	0.30	44.85	44.85
HM 50 PA 2910 + CC	4.79		2.93	2.22	0.88	0.44	0.07	0.29	44.19	44.19
HM 4.000 PA 2910	1.96			2.35	0.94	0.47	0.08	0.31	46.95	46.95
Instacoat P-4	34.50			1.57	0.63	0.32	0.05	0.21	31.36	31.36
Kollicoat IR	19.31			1.93	0.77	0.39	0.06	0.26	38.64	38.64
Metolose 65SH-1500	4.59			2.28	0.91	0.46	0.08	0.30	45.69	45.69
Pharmacoat 615	6.00			2.25	0.90	0.45	0.08	0.30	45.01	45.01

Values are given as %. AC, anhydrous caffeine; CC, caffeine citrate.

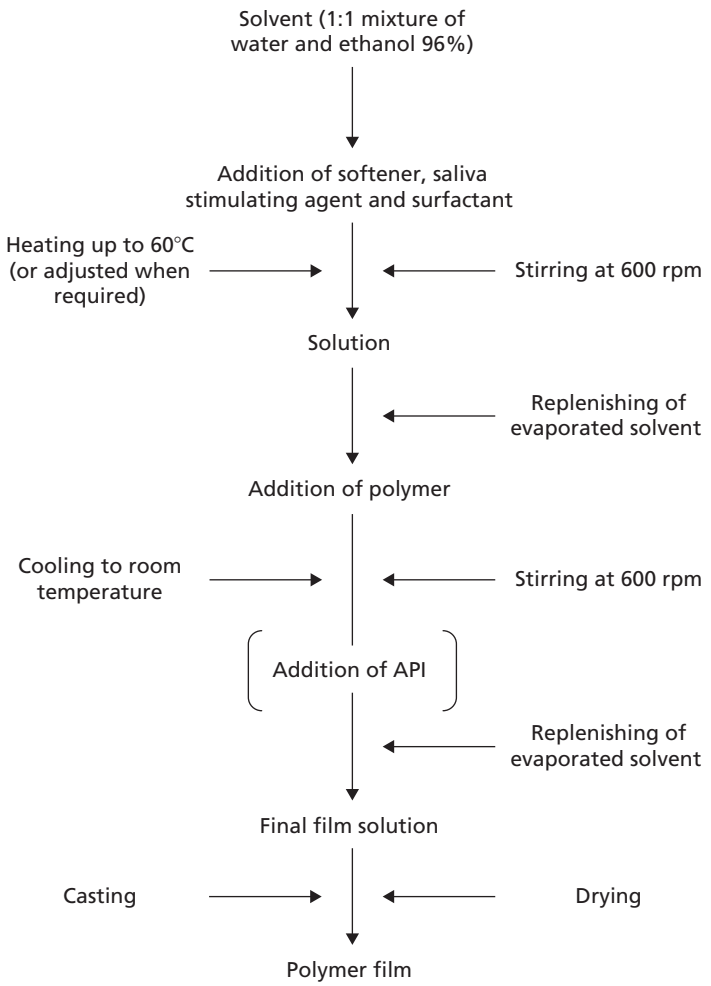

Figure 1 Method for preparation of oral films. API, active pharmaceutical ingredient

Table 3 Film thicknesses and drug content

	Film thickness (μm)		Drug content (mg/film)
	Wet	Dry	
C 30 PA 09 + CC	500	32.0 ± 13.29	5.63 ± 2.56
HM 6 PA 2910 + C	500	54.9 ± 4.29	2.95 ± 0.46
HM 6 PA 2910 + CC	500	46.2 ± 9.38	1.96 ± 0.21
HM 50 PA 2910 + C	500	42.2 ± 3.85	3.70 ± 0.65
HM50 PA 2910 + CC	500	44.5 ± 10.28	4.97 ± 0.31

Values are means ± SD (n = 5). C, caffeine base; CC, caffeine citrate.

humidity (RH) until constant weight was achieved (i.e. the weight did not change more than 0.1% within 30 min). One film was placed in each weighing unit. The data obtained were normalised according to the corresponding wet film thickness to get comparable results. The water absorption ratio was calculated as the quotient of initial mass to mass after 24 h (= constant weight).

Drug content

An automated HPLC (Hewlett Packard 1090L, Agilent, Böblingen, Germany) with UV-diode-array detector (HP1040M Series II, Agilent) was used. The analytical method was adapted from that described by Baroth.[25] The stationary phase was an RP-18 column (Hypersil ODS 125 mm × 4 mm, 5 μm; Thermo, Dreieich, Germany) and the oven temperature was 40°C. The mobile phase, containing 25% methanol (VWR, Leuven, Belgium) and 75% distilled water, was delivered isocratically at 0.9 ml/min. Caffeine CRS (EDQM, Strasbourg, France) was used as the internal standard. The peaks were evaluated at 272 nm. The method was linear between 0.5 and 500 μg/ml (r_{272nm} = 0.9991). Quintuple measurement of a 15 μl sample (6.0 mg/100 ml, CRS Caffeine) showed a precision of 1.21% at 272 nm.

Storage conditions

Oral films were stored under controlled conditions of 25°C/60% RH and 40°C/75% RH for 12 months, according to the ICH guideline Q1A(R2) 'Stability testing of new drug substances and products'. Films were clamped into slide frames for storage to prevent contact. Film thickness was determined after 0, 3, 6, 9 and 12 months.

Statistical analysis

The effect of changing the polymer on the disintegration/dissolution time in the slide frame method and Petri dish method was tested using the F-test, Student's t-test and two-way analysis of variance (ANOVA).

Results

Choice of film former

Independent of film thickness used, the C 40.000 PA 09 films were difficult to peel off the release liner and to cut into pieces. Films made of HM 4.000 PA 2910 or Pharmacoat 615 showed porous structures and were almost impossible to handle for peeling and cutting. Films made from the CMCs C 30 PA 09, C 2.000 PA 07 and C 2.000 PA 09 and the HPMCs HM 6 PA 2910 and HM 50 PA 2910 were evaluated for their suitability for use in oral films.

Disintegration/dissolution

Drug-free films

The results for the drug-free films are shown in Figure 2. Complete dissolution took less than 40 s in all cases. C 30 PA 09, C 2.000 PA 07, C 2.000 PA 09 and C 40.000 PA 09 and HM 50 PA 2910 dissolved in less than 10 s. The other HPMC films (HM 6 PA 2910, HM 4.000 PA 2910, Metolose and Pharmacoat 615) dissolved in less than 15 s. Only the oral films made from Kollicoat IR took longer than 15 s to dissolve.

Drug-loaded films

The drug-loaded polymer films made from C 30 PA 09, HM 6 PA 2910 and HM 50 PA 2910 showed higher dissolution times (5–25 s) than their equivalent drug-free formulations, which can be caused by the greater film thickness as well as the incorporation of the API (Table 4).

Although all drug-loaded films had a wet film thickness of 500 μm (Table 3), the dissolution times differed significantly between the different film formers (Table 4). A significant difference (α = 0.05) between the slide frame and Petri dish method could not be shown for C 30 PA 09 with caffeine citrate and HM 6 PA 2910 with caffeine. Compared with the drug-free formulations, the Petri dish method did not always show longer dissolution times than the slide frame method. Caffeine citrate oral films made from C 30 PA 09 had the fastest dissolution time of the drug-loaded formulations (<5 s) in the slide frame method. Caffeine and caffeine citrate films made from HM 50 PA 2910 had dissolution times of less than 10 s with both methods. Dissolution times of less than 20 s were recorded for caffeine citrate films made from HM 50 PA 2910 measured using the slide frame method, caffeine films made from HM 6 PA 2910 using the Petri dish method, and caffeine citrate films made with HM 6 PA 2910 using both methods. Dissolution times longer than 20 s were recorded for the caffeine films made from HM 6 PA 2910 using the

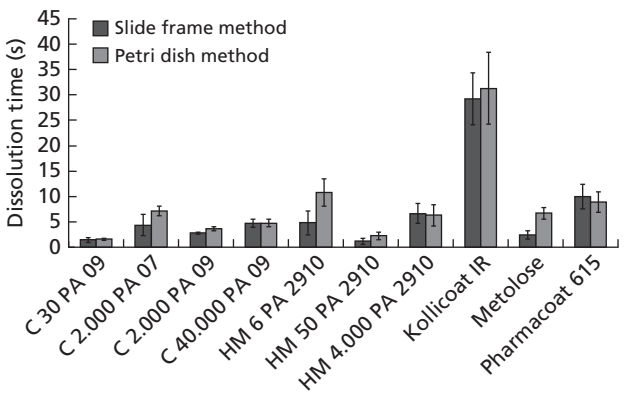

Figure 2 Dissolution times of different drug-free polymer films measured by the slide frame method and Petri dish method. Bars show mean ± confidence interval (n = 5)

Table 4 Statistical analysis (*F*- and *t*-test) of dissolution times (in s) for various film formulations with and without caffeine base or caffeine citrate

Polymer	Slide frame method			Petri dish method			*F*-test (variance)	*t*-test (mean)
	Mean	SD	s^2	Mean	SD	s^2		
C 30 PA 09	1.42	0.44	0.19	1.56	0.22	0.05		
C 2.000 PA 07	4.37	2.10	4.41	7.12	0.97	0.95		$\alpha \leq 5\%$
C 2.000 PA 09	2.78	0.23	0.05	3.70	0.41	0.17		$\alpha \leq 1\%$
C 40.000 PA 09	4.68	0.81	0.66	4.76	0.76	0.58		
HM 6 PA 2910	4.79	2.40	5.78	10.80	2.72	7.38		$\alpha \leq 1\%$
HM 50 PA 2910	1.20	0.60	0.36	2.23	0.78	0.61		$\alpha \leq 5\%$
HM 4.000 PA 2910	6.64	1.93	3.73	6.28	2.06	4.24		
Kollicoat IR	29.23	5.16	26.58	31.28	7.12	50.63		
Metolose 65SH-1500	2.44	0.80	0.64	6.70	1.16	1.35		$\alpha \leq 1\%$
Pharmacoat 615	10.01	2.40	5.78	8.93	2.00	4.00		
C 30 PA 09+CC	5.02	0.81	0.66	7.89	3.03	9.20	$\alpha \leq 5\%$	
HM 6 PA 2910+C	18.80	6.10	37.27	14.85	1.94	3.78	$\alpha \leq 5\%$	
HM 6 PA 2910+CC	12.28	4.13	17.03	10.48	2.48	6.17		
HM 50 PA 2910+C	7.37	1.31	1.72	6.60	0.88	0.78		
HM 50 PA 2910+CC	9.33	4.47	19.95	16.42	4.71	22.22		$\alpha \leq 5\%$

Values are from five samples. C, caffeine base; CC, caffeine citrate.

slide frame method and caffeine citrate films made from HM 50 PA 2910 using the Petri dish method.

Assuming a standard normal distribution, the *F*- and *t*-tests ($\alpha = 0.05$) were used to compare the two methods for each formulation. The results for the *F*-test (Table 4) revealed that the variances of the drug-free polymer films do not differ significantly from each other. However, for the drug-loaded films made of C 30 PA 09 with caffeine citrate and HM 6 PA 2910 with caffeine, the variances were significantly different. The *t*-test revealed a significant difference between the disintegration/dissolution times determined for C 2.000 PA 07, HM 50 PA 2910 and HM 50 PA 2910 loaded with caffeine citrate.

Two-way ANOVA for drug-free films showed that the null hypothesis of different mean disintegration/dissolution times for several polymer films must be rejected ($\alpha = 0.05$, $P = 7.38 \times 10^{-7}$) whereas it cannot be rejected for the data for the slide frame and Petri dish methods ($\alpha = 0.05$, $P = 0.05$). In the case of the drug-loaded films, two-way ANOVA revealed that the null hypothesis of different mean disintegration/dissolution times for several films cannot be rejected ($\alpha = 0.05$, $P = 0.11$) and neither could that for the slide frame and Petri dish methods ($\alpha = 0.05$, $P = 0.74$).

Reduction of film thickness

Oral films made from C 2.000 PA 07 showed the largest variability in this quotient during 12 months' storage at 25°C and 60% RH: 90.8–94.5% (Figure 3). The lowest variability was 95.7–96.8% for HM 50 PA 2910 (Figure 3).

Dynamic vapour sorption

During measurements at 25°C and 98% RH, all films investigated showed an increase in weight by water sorption (Figure 4). None of the film dissolved at 25°C and 98% RH.

The calculated water absorption ratio (Table 5) was highest for C 2.000 PA 09 (2.82) and C 40.000 PA 09 (2.80) and was lowest for HM 6 PA 2910 (1.99).

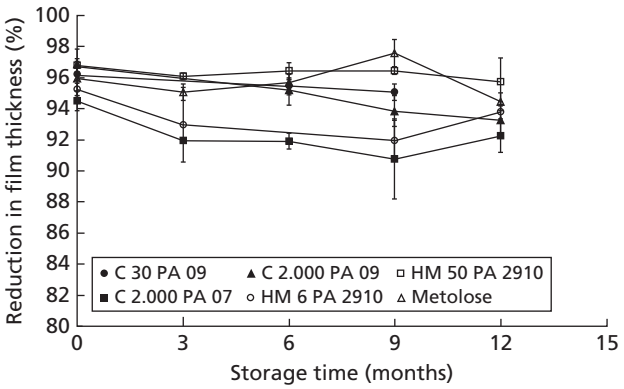

Figure 3 Reduction in film thickness from wet to dry film during storage (wet film thickness equates to 100%). Some films stuck together so thickness could not be measured. Values are means ± SD ($n = 10$)

Drug content

As can be seen in Table 3, the nominal content of 10 mg caffeine per film (6 cm^2) was not achieved in any of the polymer films. The content was lowest with caffeine-citrate-loaded HM 6 PA 2910 films (0.17 mg/cm^2) and highest with caffeine-citrate-loaded C 30 PA 09 films (0.93 mg/cm^2) but with the highest SD.

Discussion

Choice of film former

All film formers were incorporated into the same basic formulation. The oral films made of CMC were only castable when the polymer was initially dissolved in distilled water and alcohol was added in a final step. When a mixture of alcohol and water or pure alcohol was used, the polymer rapidly precipitated.

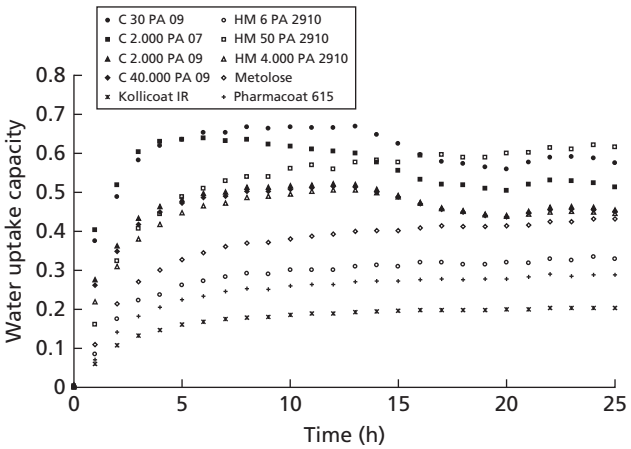

Figure 4 Water uptake capacity (%) of polymer films (%, normalised to respective wet film thickness in μm). Values shown are single measurements

Sodium alginate (Instacoat) was excluded from further investigations because the viscosity of the film solution was too low for film casting even if calcium chloride was added. Oral films of Kollicoat IR were excluded from further studies because of unpalatable taste. All remaining polymers were used for suitability studies.

Disintegration/dissolution

Two novel dissolution methods were used in this study, using a small volume of dissolution medium to simulate natural conditions. The disadvantage was that the absorption of the API could not be measured by spectral analysis. Drug-free and drug-loaded films were investigated using both methods.

Drug-free films

Classifying the results according to their wet film thicknesses, the 300 μm films (C 30 PA 09, C 2.000 PA 07, HM 6 PA 2910, HM 50 PA 2910 and Metolose) were similar. By contrast, the 400 μm films (C 2.000 PA 09, C 40.000 PA 09, HM 4.000 PA 2910, Kollicoat IR and Pharmacoat 615) were remarkably different. While C 2.000 PA 09 dissolved within 3 s (2.8 s), Kollicoat IR needed 29 s. Thus, films made of CMC or HPMC were fast dissolving and seemed to be appropriate for the intended field of application.

Table 5 Water absorption ratios calculated from water uptake capacity (single measurements)

Polymer	$Mass_{0\ h}$ (mg)	$Mass_{24\ h}$ (mg)	Water absorption ratio
C 30 PA 09	9.17	24.99	2.73
C 2.000 PA 07	8.89	22.58	2.54
C 2.000 PA 09	10.28	28.96	2.82
C 40.000 PA 09	10.02	28.08	2.80
HM 6 PA 2910	11.45	22.78	1.99
HM 50 PA 2910	6.00	13.40	2.23
HM 4.000 PA 2910	13.34	37.13	2.78
Kollicoat IR	53.37	107.85	2.02
Metolose 65SH-1500	8.95	20.52	2.29
Pharmacoat 615	18.72	45.68	2.44

Water absorption rate was calculated as $mass_{0\ h}/mass_{24\ h}$.

Drug-loaded films

We expected films made with caffeine citrate to dissolve faster than films made with anhydrous caffeine because of the better solubility of the salt, whereas in fact this assumption was founded only for HM 6 PA 2910. Films made from C 30 PA 09 with anhydrous caffeine could not be manufactured because the film solution always coalesced and did not adhere to the release liner.

Films made of CMC dissolved quickest for both drug-free and drug-loaded formulations. The two types of HPMC differ only in their degree of polymerisation; however, for processing, half the amount of HM 50 PA 2910 (Table 2) was needed to get the same viscosity of film solution. Lower dissolution times were obtained using HM 50 PA 2910. Dissolution times were shorter when less polymer was used.

Both methods allowed the disintegration/dissolution behaviour of the drug-free and drug-loaded oral films to be evaluated, and a ranking could be established, which may be useful for further pharmaceutical development. API loading in larger quantities may hinder drug release from the film matrix, which can be seen in the disintegration/dissolution test for drug-loaded films. Incorporation of an API and the subsequent changes in dissolution rate influence the disintegration and dissolution behaviour. Nevertheless, the short dissolution times obtained comply with the criterion of 3 min for fast-dissolving oral dosage forms.[26]

Reduction of film thickness

Although the films were stored in slide frames to prevent contact, some films nevertheless stuck together. Hence, values are not available for some time points during storage. Although the polymers had different wet film thicknesses and therefore different dry film thicknesses, the calculated quotient is an independent and comparable measure. In summary, the calculated quotient for the determination of the film thickness reduction seems to be a robust term, with low variability (<5%) for all polymers investigated over the 12-month period (Figure 3).

Dynamic vapour sorption

The oral films made from HPMC, except for HM 4.000 PA 2910 and Kollicoat IR, showed an increase at the beginning of the measurement cycle and slowly equilibrated to constant masses, whereas the films made from CMC showed a decrease after a rapid initial mass increase. Furthermore, the CMC films equilibrated very slowly and still maintained their original size after 24 h. All films retained their original size at the end of the measurement period.

Higher water absorption ratios were associated with faster dissolution. The films made from CMC seemed to be inappropriate for use at high RH because of the high initial water sorption, which makes the films sticky and unsuitable for this application.

Drug content

After pre-evaluation, C 30 PA 09, HM 6 PA 2910 and HM 50 PA 2910 were used for preparation of drug-loaded

films. The free caffeine base and water-soluble salt caffeine citrate were chosen as APIs. However, experiments were only successful with the HPMC grades. It was not possible to prepare CMC films with anhydrous caffeine because the films coalesced during drying.

A drug load of 10 mg per oral film (6 cm^2), which corresponds to 1.67 mg/cm^2, was intended. Given the ratio of molar masses of 1 : 2 for caffeine base (194.19 g/mol) to caffeine citrate (386.62 g/mol), double the amount of caffeine citrate was weighed. All film solutions were cast with a thickness of 500 μm (Table 3).

The drug content of 10 mg per 6 cm^2 was determined by calculation of nominal weight per area unit (6 cm^2). However, this weight varies depending on different film thicknesses. Our data show that it is not appropriate to choose the film thickness that achieves this nominal weight on the basis of a single measurement and then extrapolate this data to the other polymers. The film thickness, and thus weight of film per area, has to be adjusted to achieve the nominal drug content individually for each polymer, which will make comparison of the disintegration/dissolution times possible and allow these and drug content to be established.

Conclusions

We have evaluated different film formers for their suitability in fast-dissolving oral dosage forms. Several polymers were not suitable for the intended use because of poor quality (C 40.000 PA 09, HM 4.000 PA 2910 and Pharmacoat 615) or unpalatable taste (Kollicoat IR). Film solutions made of sodium alginate could not be properly cast. Dissolution occurred within 40 s. Content uniformity differed greatly between the polymers investigated, even though equal wet film thicknesses and equal amounts of API were considered. In all cases, the nominal content could not be achieved, implying that film thickness for a particular drug load must be determined individually for each API and polymer. In this case study, the HPMCs seem to have the most appropriate qualities for use in oral films for caffeine/caffeine citrate because of their fast dissolution and homogenous API distribution within the oral films obtained.

Declarations

Conflict of interest

The Author(s) declare(s) that they have no conflicts of interest to disclose.

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