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Preparation, characterization, and tabletting properties of a new cellulose-based pharmaceutical aid

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Abstract

A new cellulose-based tabletting excipient, hereinafter referred to as UICEL, has been developed by treating cellulose powder with an aqueous solution of sodium hydroxide (conc. $\geq$ 5N) and subsequently precipitating it with ethyl alcohol. UICEL is similar in structure to Avicel® PH-102, a commercial direct compression excipient commonly referred to as microcrystalline cellulose (MCC). It, however, shows the cellulose II lattice, while Avicel® PH-102 belongs to the cellulose I polymorphic form. As produced, UICEL consisted of a mixture of aggregated and non-aggregated fibers. The degrees of polymerization (DP) and crystallinity (DC) of UICEL, determined by the viscosity and powder X-ray methods, were 189–207 and 47–58%, respectively. Avicel® PH-102, by comparison, showed an aggregated structure with DP and DC values corresponding to 248 and 76.9%, respectively. Compared to Avicel® PH-102, UICEL shows higher true density, bulk density, tap density, Carr's index and Hausner ratio values. The mean deformation pressure (P_y) values calculated from the linear portion of the Heckel plots for UICEL and Avicel® PH-102 were about 104 and 87 MPa, respectively, suggesting that UICEL is less ductile than Avicel® PH-102. The hardness values of UICEL tablets increased nearly linearly with increasing compression pressures. Comparatively, Avicel® PH-102 formed stronger tablets. Irrespective of the compression pressure used, all UICEL tablets disintegrated within 15 s, whereas Avicel® PH-102 tablets of comparable strengths remained intact for over 12 h. In conclusion, the results show that UICEL can be used as a direct compression excipient, especially in the design and development of fast-disintegrating tablets.

Keywords: UICEL; Avicel®; Microcrystalline cellulose; Cellulose excipient; Direct compression excipient

1. Introduction

The preparation of tablets by direct compression has steadily increased due to the ease of manufacture. Currently, microcrystalline cellulose (MCC) and powdered cellulose (PC) are the most commonly used direct compression excipients. MCC is produced by reacting cellulose with an aqueous solution of a strong mineral acid at boiling temperature for a period until the level-off degree of polymerization (level-off DP) of cellulose is obtained (Battista and Smith, 1961). PC, in contrast, is prepared by mechanical disintegration of cellulose (Morse, 1981, 1984). Both MCC and

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PC are currently commercially available in different grades under various trade names. Depending on the starting cellulose source and processing variables used during their manufacture, MCC and PC products may vary in physicochemical properties, and consequently, also in their performance as direct compression excipients (Doelker et al., 1987; Landin et al., 1993a,b; Parker et al., 1988; Roberts and Rowe, 1987).

Recently, a new direct compression excipient called low crystallinity powdered cellulose (LCPC), ranging in degree of crystallinity from 15 to 45%, has been developed (Wei et al., 1996). It is produced by reacting cellulose with phosphoric acid first at room temperature for 1 h and then at 45–75 °C for 2–10.5 h, followed by adding the resulting highly viscous solution in water. Kothari (1998) has found that depending on the agitation rates used during the regeneration step in water, LCPC products with different powder and mechanical properties are produced. Compared to MCC and PC, LCPC has been shown to possess superior properties as a binder (Wei, 1991; Kothari, 1998).

The use of alkali metal hydroxides as swelling agents for cellulose has been extensively investigated (Krassig, 1996; Lin et al., 1992, 1991; Wood et al., 1989). The objectives of the studies were: (i) to convert cellulose into alkali celluloses for use in the preparation of cellulose derivatives, such as cellulose ethers, cellulose esters, cellulose xanthates, etc.; (ii) to improve the physical and chemical characteristics of cellulose, especially its reactivity with other agents; (iii) to study the hydrolysis kinetics of mercerized celluloses; (iv) to increase dye affinity, improve luster and smoothness, and achieve dimensional stability and raise tensile strength of fibers in the fabric; and (v) in the processing of cellulose fibers and films.

In this study, we have investigated, for the first time, the use of sodium hydroxide treated cellulose powder as a direct compression excipient. We have found that cellulose-derived powders (e.g. MCC, PC, and LCPC), when soaked in an aqueous solution of sodium hydroxide and subsequently precipitated by ethanol, result in a material (hereinafter referred to as UICEL), that can be compressed into a tablet, with or without the aid of a binder. The resulting tablet rapidly disintegrates in water, suggesting that UICEL can be used as a direct compression excipient, especially in the design and development of fast-disintegrating tablets. In this paper, we report the method of preparation of UICEL and compare its powder and tabletting properties with that of Avicel® PH-102, a commercial MCC-based direct compression excipient manufactured and marketed by FMC Corporation (Princeton, NJ).

2. Experimental

2.1. Materials

Cotton linter sheets (grade R270), the starting cellulose source, were obtained from Southern Cellulose Products, Inc. (Chattanooga, TN). Hydrochloric acid, sodium hydroxide, and ethanol were purchased from Fisher Scientific (Fair Lawn, NJ). Avicel® PH-102 was received from FMC Corporation (Philadelphia, PA).

2.2. Preparation of UICEL

280 g of cotton linter sheet, cut into small pieces, and 2-l of 1 N HCl were placed in a 5-l round-bottomed flask, equipped with a condenser and a mechanical stirrer. The reaction mixture was allowed to stand at room temperature for 1 h and then heated at boiling temperature. Once the cotton linter pieces were broken into small fibers, the stirring was started. The heating was continued for another 1.5–2 h with constant agitation. The reaction mixture was then cooled to room temperature and filtered. The white residue obtained was washed with water until the filtrate showed a near neutral pH and then air-dried (yield $>85\%$).

One hundred grams of the dried powder, or an equivalent amount of the wet residue obtained after the washing step, was added in portions to an aqueous solution of sodium hydroxide with constant stirring. The volume and concentration of the sodium hydroxide solution were adjusted to the following specifications. The weight to volume ratio of cellulose to sodium hydroxide solution

was 1:6. The concentration of sodium was 5, 7.5, or 10 N. The cellulose–sodium hydroxide mixture (gel) was allowed to stand at room temperature for either 4 or 12 h. Ethyl alcohol (190 proof), in amounts sufficient to give a final concentration of 50 or 60% in the mixture, was then added. An immediate precipitation of white powder occurred. The precipitate was washed with water until the filtrate showed a near neutral pH. The resulting wet white solid was spread on a Teflon-coated tray and air-dried until it passed freely (without blocking the screen's holes) through a US # 20 screen. The sieved material was then dried in an oven at 45–50 °C until it showed a moisture content value of 6% or less (yield ≥ 90%).

2.3. Characterization methods

UICEL and Avicel® PH-102 products were fractionated on a Cenco–Meinzer sieve shaker (Central Scientific Co., Chicago, IL). The fraction that contained particles ranging in size from 140 to 200 mesh, corresponding to an average particle size of about 90 μm, was used in the study.

2.3.1. Loss on drying, residue on ignition, and heavy metals tests

These tests were performed according to the procedures described in the US Pharmacopoeia/National Formulary (USP/NF, 1999a) for MCC.

2.3.2. Scanning electron microscopy (SEM)

The SEM of the UICEL and Avicel® PH-102 samples were obtained using a Hitachi S-4000 microscope. The samples were loaded on aluminum stubs covered with a double-sided tape. They were then coated with a gold/palladium (60/40) mixture for 4 min in an Emitech K550 coater.

2.3.3. Fourier-transform infrared (FT–IR) spectroscopy

The FT–IR spectra of products were obtained as KBr pellets on a Nicolet 5DXB infrared spectrophotometer.

2.3.4. Solid state carbon-13 cross-polarization/magic angle spinning nuclear magnetic resonance (^{13}C CP/MAS NMR) spectroscopy

The solid-state ^{13}C CP/MAS NMR spectra of samples were obtained on a Bruker MSL-300 spectrometer using the true 90° pulse calibration time of 6 μs and the proton transmitter dead time of 2 μs. The contact time for polarization transfer with Hartmann–Hahn match was 3 μs. The data acquisition time was 29 μs. A spectrum width of about 510 ppm was acquired, but only the region between 0 and 200 ppm was plotted. The number of scans for all spectra was 1200.

2.3.5. Degree of polymerization (DP)

The degree of polymerization of samples was determined by the viscosity method (ASTM, 1965; Kumar and Kothari, 1999) at 25 ± 0.5 °C using an Ostwald capillary viscometer (Size 50) and cupriethylenediamine hydroxide (Cuen) as the solvent, according to the relationship: $[\eta] = 190 \times \mathrm{DP}$, where 190 is a constant determined by Grobe (1989) for cellulose from a plot between the intrinsic viscosity and degree of polymerization obtained from absolute molecular weight determination methods, and $[\eta]$ is the intrinsic viscosity of the solution. The latter was calculated by interpolation using the USP table (USP/NF, 1999b) that lists the predetermined values of the product of intrinsic viscosity and concentration, ($[\eta]$C) for cellulose samples exhibiting relative viscosity (η_{rel}) values between 1.1 and 9.9. η_{rel} was calculated using the relationship: $\eta_{rel} = t/t_0$, where t and t_0 are the efflux times for the cellulose solution and cuen (blank) solvent, respectively.

2.3.6. Powder X-ray diffractometry

The powder X-ray diffraction (XRD) measurements were conducted over a 5–40° 2θ range on a Siemens Model D5000 diffractometer, equipped with monochromatic CuKα ($\alpha_1 = 1.54060$ Å, $\alpha_2 = 1.54438$ Å) X-rays. The step width was 0.020° 2θ/min with a time constant of 0.5 s. The integration of the crystalline reflections was achieved using the Diffrac^{Plus} diffraction software (Eva, Version 2.0, Siemens Energy and Automation, Inc. Madison, WI). The degree of crystallinity of

samples was expressed as the percentage ratio of the integrated intensity of the sample to that of hydrocellulose, a crystalline standard prepared from cellulose by treatment with 2.5 N HCl at boiling temperature, as has been reported previously (Kumar and Kothari, 1999).

2.3.7. True density

The true density of the samples was determined using a Quantachrome Model MPY-2 helium displacement pycnometer (Quantachrome Corporation, Syosset, NY). The pycnometer was calibrated before use. All samples were dried at room temperature under reduced pressure for 24 h prior to analysis. The true density was calculated using the equation: $\rho_{true} = w/v_p$, where ρ_{true}, w, and v_p are true density, weight of the sample, and true volume of the powder, respectively.

2.3.7.1. Bulk and tap densities. An appropriate amount of the sample was poured in a 50 ml tarred graduate cylinder. The cylinder was lightly tapped twice to collect all the powder sticking on the wall of the cylinder. The volume was then read directly from the cylinder and used to calculate the bulk density according to the relationship: mass/volume. For tap density, the cylinder was tapped 500 times using a Vankel tap density analyzer. The volume of the sample was then read and used in the calculation.

2.3.8. Porosity

The porosity of the test powders was determined using the equation $\varepsilon = (1 - \rho_{tap}/\rho_{true})$ 100, where ε, ρ_{tap}, and ρ_{true} are porosity, tap density, and true density of the powder, respectively.

2.3.9. Carr's index and Hausner ratio

The Carr's index (Carr, 1965) and the Hausner ratio (Hausner, 1967) were calculated using the equation $[(\rho_{tap} - \rho_{bulk})/\rho_{tap}] \times 100$ and ρ_{tap}/ρ_{bulk}, respectively.

2.3.10. Preparation of tablets

Tablets of UICEL and Avicel® PH-102, each weighing about 500 mg, were prepared on a Carver hydraulic press at different compression pressures, ranging from about 10 to 147 MPa using a 13-mm diameter die and flat-face punches and a dwell time of 30 s.

2.3.11. Heckel analysis

The porosity (ε) of the compacts was calculated using the relationship $\varepsilon = (1 - \rho_{app}/\rho_{true})$, where ρ_{app} is the apparent density of the compact and ρ_{true} is the true density of the particles. The apparent density (ρ_{app}) of the compact was calculated from the ratio of the tablet mass to the volume of the compact. The latter, at a given pressure, was calculated according to the equation: $v = \pi r^2 h$, where v is the volume, r is the radius, and h is the thickness of the compact. The tablet thickness is expressed as averages of five measurements, made after about 16 h of tablet production, and at five different points between the two surfaces of the tablet.

The Heckel plots were constructed by plotting the natural log of the inverse of the compact porosity against the respective compression pressures. Regression analysis was performed on the linear portion of the curve, and the slope value obtained was converted to mean deformation pressure (P_y) using the relationship: $P_y = 1/\text{slope}$.

2.3.12. Hardness test

The hardness of tablets was measured using a Vanderkamp hardness tester. The hardness values reported are an average of three measurements.

2.3.13. Disintegration studies

The disintegration test was performed in water at 37 °C using an Erweka GmbH apparatus (type 712, Erweka, Offenbach, Germany). The disintegration times reported are averages of three determinations.

3. Results and discussion

3.1. Preparation and characterization of UICEL

Cellulose powders when soaked in an aqueous sodium hydroxide solution (conc. ≥ 5 N) readily formed a gel. The use of 2.5 N sodium hydroxide solution failed to produce UICEL. It is important that the cellulose powder be added to the sodium

hydroxide solution in portions and with constant agitation. This facilitates rapid dispersion of the powder into the solution, and consequently, the formation of a homogeneous gel. The precipitation of the gel with ethanol is critical to the preparation of UICEL. The use of other solvents such as acetone resulted in a powder that, upon compaction, produced tablets that did not disintegrate as rapidly as the product obtained using ethanol. The use of water instead of ethanol converts the gel into a colloid, which was difficult to process. Other approaches, such as neutralization of the gel with an acid, followed by washing the solid with water, also failed to produce the desired product.

UICEL, as produced, showed the residue on ignition and heavy metal content values of 0.044% and $< 0.001\%$, respectively.

Fig. 1 compares the SEM photographs of UICEL and Avicel® PH-102. UICEL consisted of a mixture of aggregated and non-aggregated fibers, whereas Avicel® PH-102 showed an aggregated structure composed of small fibers with coalesced boundaries. In general, UICEL particles are smaller compared to those of Avicel® PH-102. The differences seen in the morphology and size of UICEL and Avicel® PH-102 are attributed to different manufacturing conditions employed. Avicel® PH-102 is a level-off DP cellulose product, and is prepared by spray drying. UICEL, as noted in the experimental section, is produced under controlled hydrolysis conditions, followed by drying first at room temperature and then in an oven at 45–50 °C.

The powder X-ray diffractograms of UICEL and Avicel® PH-102 are shown in Fig. 2. The

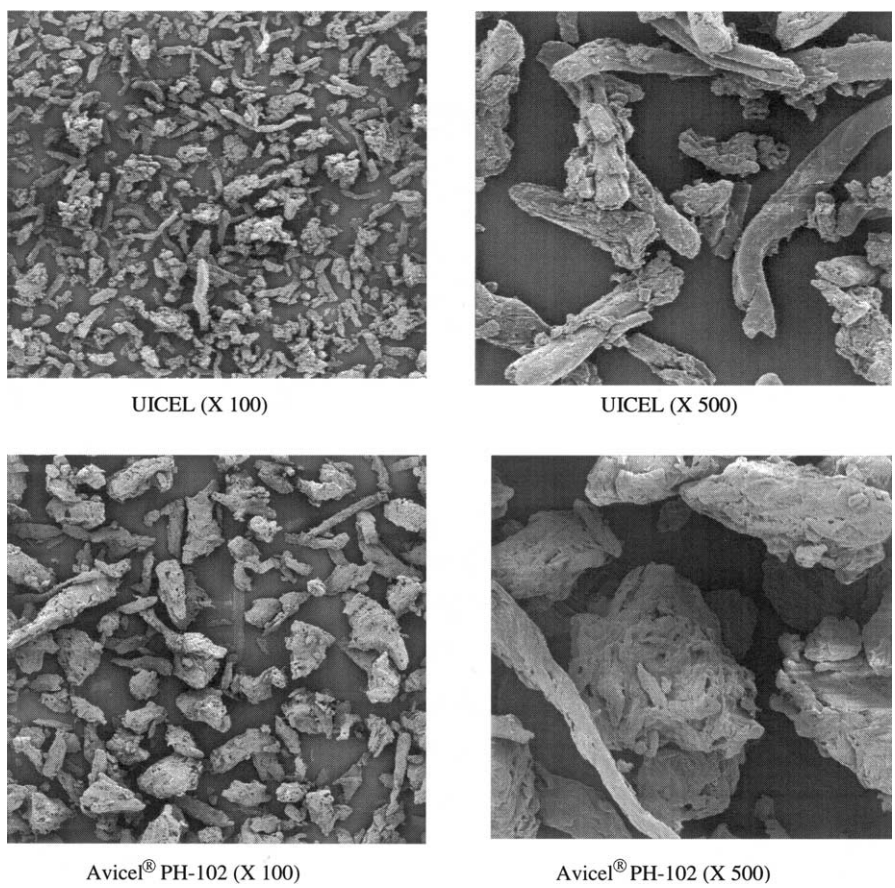

Fig. 1. SEM photographs of UICEL and Avicel® PH-102.

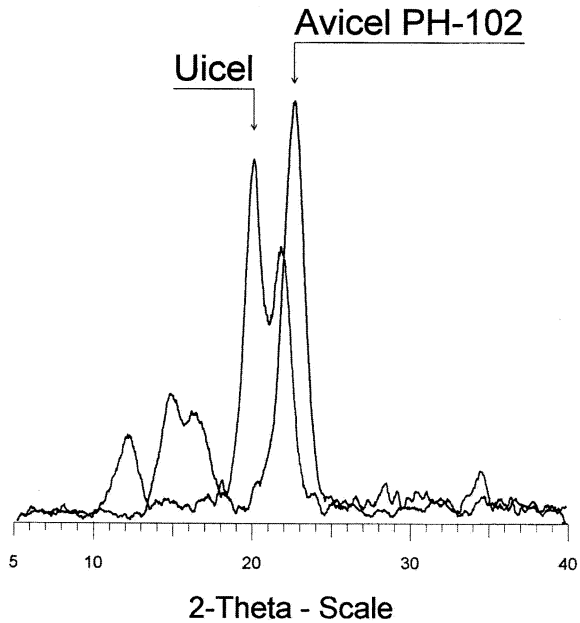

Fig. 2. Powder X-ray diffractograms of UICEL and Avicel® PH-102.

Table 1
Degree of crystallinity of UICEL products

Concentration and soaking duration of NaOH	Diffraction peaks (° 2θ)	Degree of crystallinity (%)
NaOH concentration (N)		
5.0	11.859, 19.983, 21.821	46.99
7.5	11.978, 20.042, 21.702	49.30
10.0	12.156, 19.983, 21.702	47.58
Soaking duration (h)[a]		
4	11.859, 19.983, 21.821	48.33
12	11.998, 20.062, 21.740	56.98

[a] NaOH concentration 5.0 N.

diffraction peaks appearing at about 12, 20, and 22° 2θ (due to 101, 10$\bar{1}$, and 002 reflections, respectively) in the diffractogram of UICEL are indicative of the presence of the cellulose II lattice, similar to that present in mercerized celluloses prepared from ramie and cotton fibers (Krassig, 1996) and LCPC regenerated from concentrated (85% w/w) phosphoric acid solution in water at an agitation rate of 4000 r.p.m. (Kothari, 1998; Kumar et al., 2001). Avicel® PH-102, in contrast, shows reflections that are characteristics of the cellulose I lattice (Kumar and Kothari, 1999). Recently, a MCC product from Japan, which is predominantly cellulose I, has also been found to contain a small percentage of cellulose II (Landin et al., 1993a).

The degree of crystallinity of UICEL ranged between about 47 and 57% (Table 1). These results are in good agreement with the values (51–62%) reported for mercerized cotton prepared by treatment with 18% sodium hydroxide solution at 0 °C (Krassig, 1996). The concentration of sodium hydroxide solution had no effect on the crystallinity of UICEL. However, when the soaking time (sodium hydroxide concentration 5.0 N) was increased from 4 to 12 h, the crystallinity of UICEL increased from about 48 to about 57%. A further increase in soaking time caused no further change in the crystallinity of UICEL. As can be seen in Fig. 3, the ratio of the X-ray peak intensities at 20.1° 2θ and 21.8° 2θ significantly increased on increasing the soaking time from 4 to 12 h, suggesting that the crystallization of the cellulose chains occurred to a greater extent in the 10$\bar{1}$ plane of the crystal lattice than that in the 002 plane. The degree of crystallinity of Avicel® PH-102 was about 76.9%. This difference in the crystallinities of UICEL and Avicel® PH-102 is attributed to the different crystal lattices present in the two materials. In cellulose I, the chains are arranged in a parallel manner, whereas cellulose II shows an anti-parallel arrangement of chains (Krassig, 1996). The different chain arrangements result in different interchain and intrachain hydrogen bonding networks, and consequently, a different degree of crystallinity. Studies show that cellulose II possesses additional hydrogen bonding between chains at the corners and the centers of the unit cells and as a result is more stable than cellulose I (Krassig, 1996).

The FT–IR spectra of UICEL and Avicel® PH-102 are compared in Fig. 4. The two spectra

appear similar except for the following notable differences: (i) the characteristic intermolecular and intramolecular O–H stretching vibration band in the spectrum of UICEL appears more broad and shows the maximum intensity at 3443 cm^{-1}. In the case of Avicel® PH-102, this band occurs at 3346 cm^{-1}; (ii) the peaks at 1431 cm^{-1} and 1316 cm^{-1}, which are associated with the intramolecular hydrogen bonds at the C_6 group and O–H in-plane bending vibration, respectively, are less strong in UICEL than in Avicel® PH-102; and (iii) the absorption band at 894 cm^{-1} in the spectrum of UICEL, attributable to antisymmetric out-of-phase stretching vibration, is relatively stronger in intensity than that in Avicel® PH-102. It has been reported that the intensity of this peak increases with a decrease in the crystallinity of the cellulose sample and a change in the crystal lattice from cellulose I to cellulose II (Krassig, 1996). Thus, the higher intensity of this peak seen for UICEL compared to that of Avicel® PH-102 indicates that the former is the low crystallinity material and contains the cellulose II lattice. These results are in agreement with those obtained by the powder X-ray diffraction method. A list of important infrared peaks, along with their assignments, for valonia cellulose, cellulose I, ramie cellulose, and cellulose II can be found in Polymer Handbook (Grobe, 1989).

The carbon-13 CP/MAS spectra of UICEL and Avicel® PH-102 are depicted in Fig. 5. The peaks were assigned on the basis of the spectral data reported in the literature for various unmodified celluloses (Atalla et al., 1980; Nehl et al., 1994). Thus, by analogy, the peaks at 106.4, 87.5 and 62.5 ppm are due to C-1, C-4, and C-6 carbons, whereas the carbon resonance at 74.6 is attributed to C-2, C-3, and C-5. In the spectrum of Avicel® PH-102, the peak appearing at about 84 ppm, not seen in the spectrum of UICEL, is assigned to C-4 located in the amorphous regions.

The selected powder properties of UICEL and Avicel® PH-102 are compared in Table 2. Owing to its non-aggregated, fibrous structure, UICEL is less porous and shows higher bulk, and tap densities compared to that of Avicel® PH-102. The higher moisture content observed in UICEL could be due to its lower degree of crystallinity, which causes more hydroxyl groups to be accessible for interaction with water molecules. The different cellulose chain arrangements, and consequently, the hydrogen bonding network, in UICEL com-

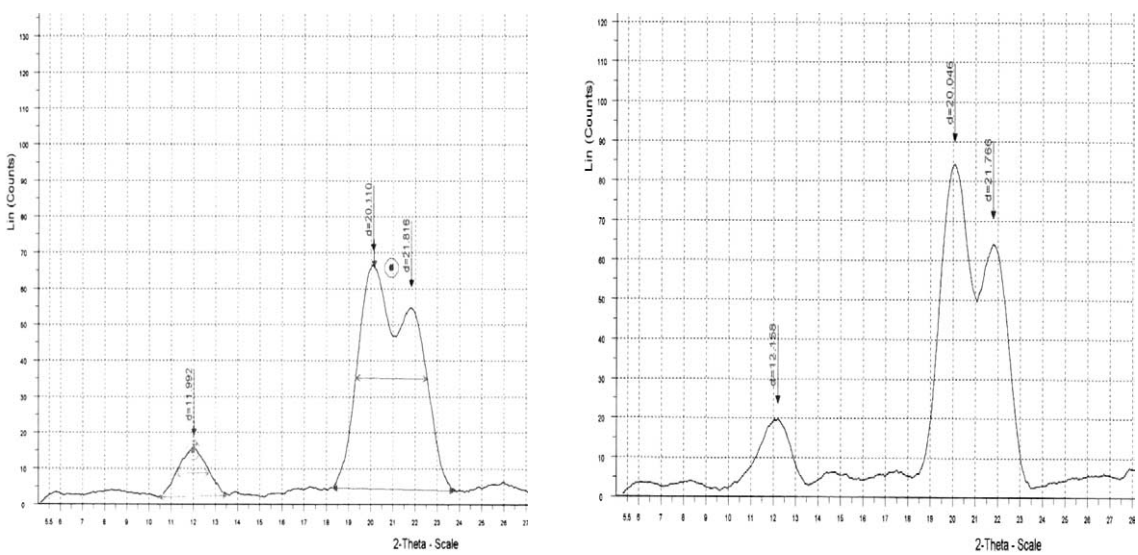

Fig. 3. Powder X-ray diffractograms of UICEL prepared after soaking for (A) 4 h and (B) 12 h in 7.5 N NaOH solution.

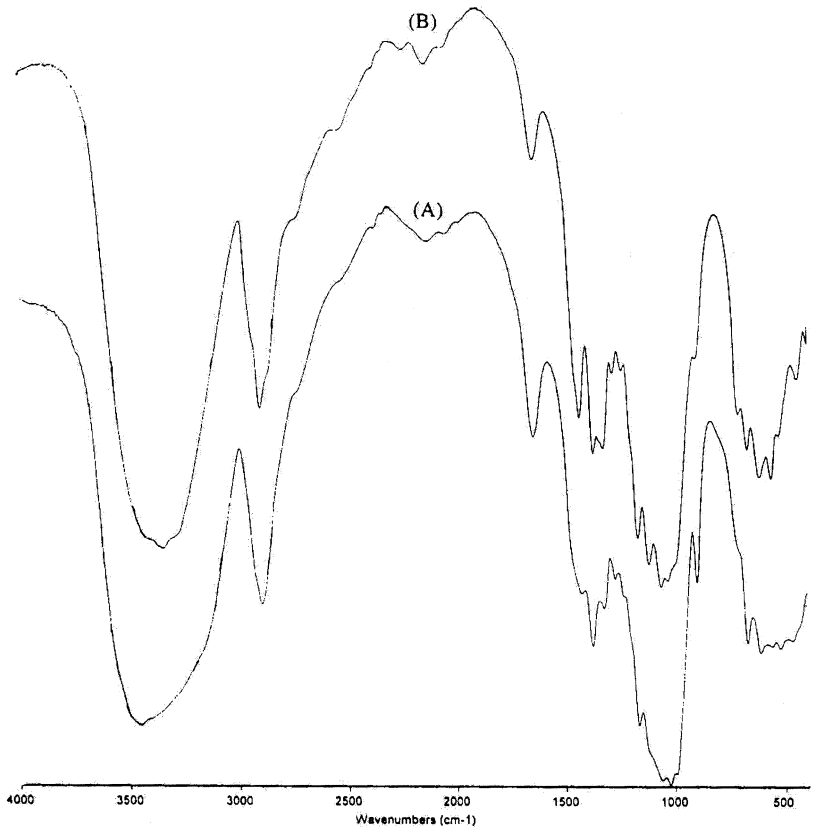

Fig. 4. FT–IR spectra of (A) UICEL and (B) Avicel® PH-102.

pared to that in Avicel® PH-102 may also contribute to its increased affinity for water molecules. The average degrees of polymerization (DP) values of UICEL and Avicel® PH-102 were 198 and 248, respectively.

The Hausner ratio and the Carr index have been widely used to estimate the flow properties of powders. A Hausner ratio of less than 1.20 is indicative of good flowability of the material, whereas a value of 1.5 or higher suggests a poor flow display by the material (Wells, 1988). The Carr index values of 5–10, 12–16, 18–21, and 23–28 indicate excellent, good, fair, and poor flow properties of the material, respectively (Carr, 1965). The Hausner ratio and the Carr index values obtained for UICEL and Avicel® PH-102 are listed in Table 2. These results suggest that both UICEL and Avicel® PH-102 possess fair to good flow properties. The slightly higher Hausner and Carr index values of UICEL, compared to that of Avicel® PH-102, were expected because of its fibrous structure, which facilitates entanglements between particles, and consequently, displays poor flow properties relative to that of Avicel® PH-102. However, the relatively higher bulk and tap densities of UICEL should be advantageous in tabletting, especially in making tablets with high dose drugs, because the volume of die-fill would be correspondingly reduced.

3.2. Tabletting properties of UICEL

The Heckel analysis is routinely performed to study the effect of applied pressure on the relative density of a powder bed during compaction and to determine the deformation mechanism of particles forming the compacts (Alderborn and Nystrom, 1996). In this study, the Heckel plots for

UICEL and Avicel® PH-102 were constructed over a compression pressure range from 10 to 137 MPa (Fig. 6). Table 3 lists the compression pressure ranges over which the regression analysis was performed, the regression analysis results, and the 1/slope (yield pressure) values. The densification of UICEL and Avicel® PH-102 increased with increasing compression pressures. A closer examination of the Heckel curves clearly showed two linear regions followed by a plateau region. Podczek and Revesz (1993) reported that materials with a 1/slope value of less than 80 MPa deform mainly by plastic flow, and as this value increases the materials become more and more brittle. Thus, from the 1/slope values listed in Table 3, it can be concluded that UICEL is less ductile than Avicel® PH-102.

The relationship between hardness of UICEL and Avicel® PH-102 tablets and the respective applied pressure is shown in Fig. 7. These results clearly show that Avicel® PH-102 formed stronger tablets than UICEL.

The disintegration times of UICEL tablets, irrespective of their hardness value, varied between 5 s and 11 s (Fig. 8), whereas Avicel® tablets of comparable strength remained intact for over 12 h.

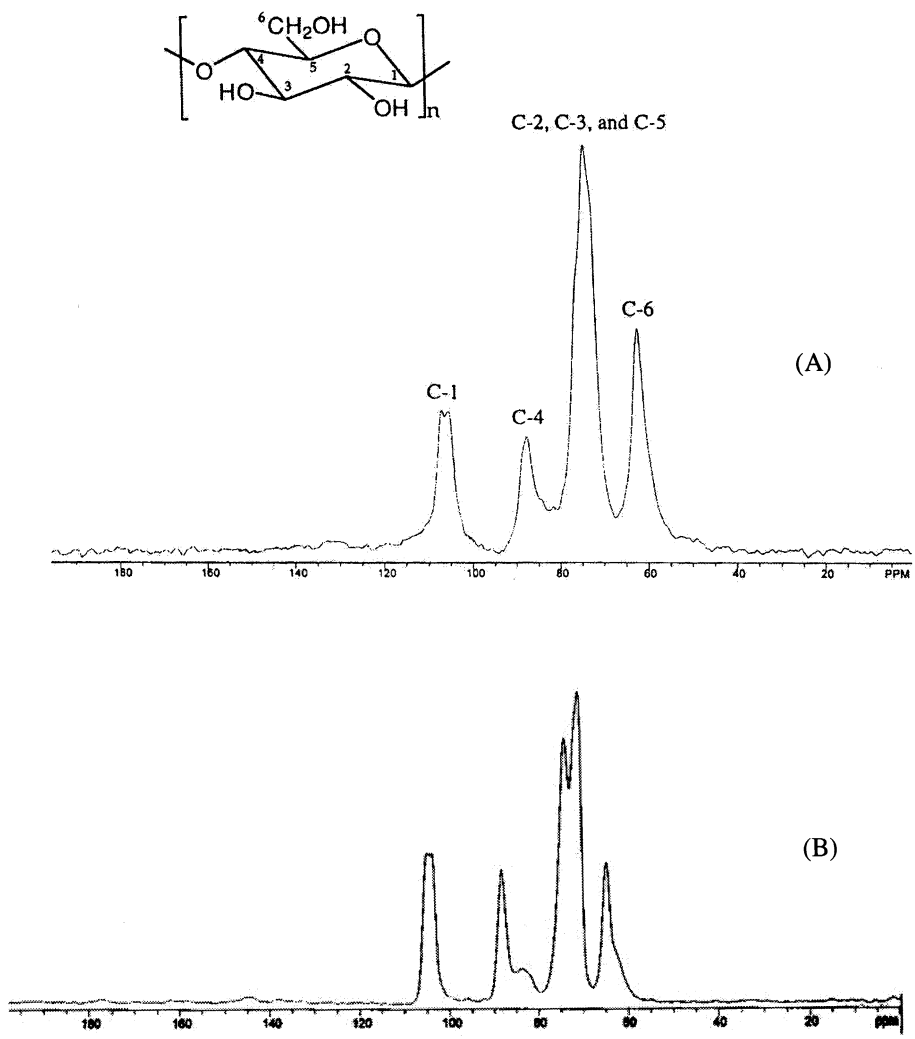

Fig. 5. Carbon-13 CP/MAS NMR spectra of UICEL and Avicel® PH-102.

Table 2
Powder properties of UICEL and Avicel® PH-102

	UICEL	Avicel® PH-102
Moisture content (%)	3.20 (0.05)	1.76 (0.07)
True density (ρ_{true}, g/ml)	1.531 (0.002)	1.577 (0.004)
Bulk density (ρ_{bulk}, g/ml)	0.449 (0.001)	0.332 (0.009)
Tap density (ρ_{tap}, g/ml)	0.573 (0.003)	0.403 (003)
Hausner ratio	1.28 (0.01)	1.21 (0.03)
Carr's index	21.63 (0.55)	17.51 (2.37)
Porosity (%)	62.6	73.6
Degree of polymerization	189–207	248
Degree of crystallinity (%)	47.0–57.0	76.9

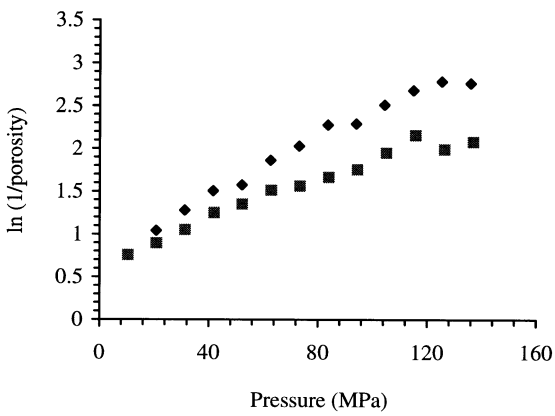

Fig. 6. Heckel plots for UICEL (■) and Avicel® PH-102 (◆).

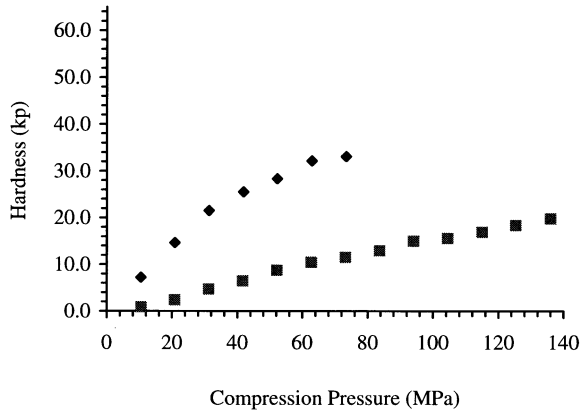

Fig. 7. Relationship between compression pressure and hardness of UICEL (■) and Avicel® PH-102 (◆) tablets.

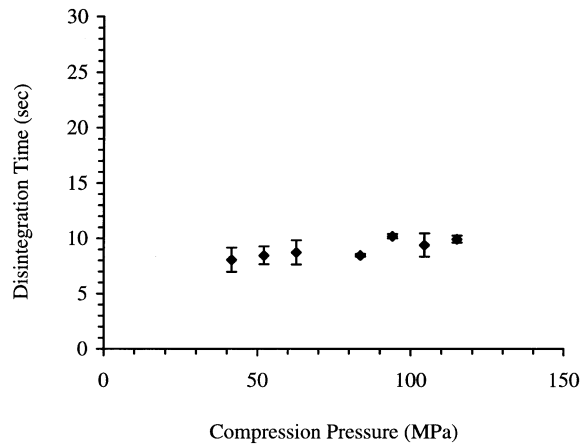

Fig. 8. Relationship between compression pressure and disintegration time of UICEL tablets.

It is recognized that Avicel® is a good wicking agent. But, it does not swell and, on its own, does not disintegrate. However, with the addition of a small amount of a swelling agent, such as starch, Avicel® tablets disintegrate rapidly. UICEL offers a definite advantage over Avicel® PH-102 in that it does not need any additional disintegrant.

Table 3
Heckel analysis results

	Compression pressure range (MPa)	R^2	Slope	1/Slope (MPa)
UICEL	10–42	0.9936	0.0158	63.29
	63–94	0.9821	0.0079	126.58
Avicel® PH-102	10–42	0.9966	0.0239	41.84
	52–94	0.9909	0.0216	46.30
	94–114	0.9994	0.0183	54.65

The results presented above clearly show that Avicel® PH-102 is a strong binder, while UICEL acts as a binder and as a highly effective disintegrant. This unique property of UICEL is important in the design and development of immediate-release tablet dosage forms, especially of poorly soluble drugs.

4. Conclusion

Cellulose powders, when soaked in sodium hydroxide solution and subsequently precipitated with ethyl alcohol, washed with water to neutrality, and then dried, result in a product that can be compressed into a tablet, without the need of a binder. The resulting tablets, irrespective of the strengths, rapidly disintegrate in water to the original powders used to make the tablets. UICEL, as produced, is predominantly a fibrous material consisting of the cellulose II lattice. Compared to Avicel® PH-102, UICEL is more dense and less ductile. The higher density of UICEL is important in tabletting because the volume of the die-fill would be correspondingly decreased. In conclusion, the results presented show that UICEL has the potential to be used as a direct compression excipient, especially in the design of fast-disintegrating tablets.

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