

Characteristics of Compressed Microcrystalline Cellulose from Empty Fruit Bunch Fibre

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INTRODUCTION

Microcrystalline cellulose (MCC) powder was prepared by acid treatment of the cellulose extracted from oil palm empty fruit bunch (EFB) fibre (Ramli *et al.*, 2015; Rosnah *et al.*, 2009). Traditionally MCC was obtained from wood, cotton (Suzuki and Nakagami, 1999), and cotton linters (Nada *et al.*, 2009). There are a few reports of MCC derived from agriculture biomass such as rice straw and bagasse (Ilindra and Dhake, 2008), sawdust (Oyeniya and Itiola, 2012), kenaf core wood (Chi *et al.*, 2013), *Lageriana siceraria* (water gourd) (Achor *et al.*, 2014), soyabean hulls (Merci *et al.*, 2015), oil palm fronds (Hussin, *et al.*, 2016) and oil palm trunks (Abd Hamid *et al.*, 2014).

In general, MCC functions as an anti-caking agent, as a stabiliser (Ahmadi *et al.*, 2015; Mascia *et al.*, 2010), and to extend starches, texturing agents and fat replacers (Gibis *et al.*, 2015) in the food and beverage, cosmetics and animal feed industries (Schuh *et al.*, 2013). Another application of MCC is in the pharmaceutical industry for the preparation of drug pills in the form of tablets, capsules and pellets (Chamsai and Sriamornsak, 2013).

Owing to their high compactability property, MCC tablets can be produced by granulation or direct compression with low pressure (DFE Pharma, 2013). Compressed MCC seems to act as a diluent and as a disintegrant (Kalita *et al.*, 2013; Saigal *et al.*, 2009). The first direct compressed

tableting from commercial MCC was Avicel® PH, which was produced by FMC Corporation (Albers *et al.*, 2006). The purpose of this article is to evaluate the suitability of EFB-based MCC for pharmaceutical use.

MATERIALS AND METHODS

Materials

The EFB fibre was obtained from Szetech Engineering, Malaysia, in the form of shredded fibre with moisture content of 10%-15%. Standard commercial MCC 101 of USP grade was purchased from Hangzhou Ruijiang Chemicals Co. Ltd.

Preparation of holocellulose, α -cellulose and MCC

Holocellulose and α -cellulose from EFB were prepared according to ASTM D1104-56 and ASTM D1103-60, respectively. The detailed characteristics and morphology of α -cellulose have been described in our previous paper (Rosnah *et al.* 2012).

The preparation of MCC is according to our published paper (Rosnah *et al.*, 2009). The detailed characteristics and morphology of EFB-based MCC were also described in the same paper.

Moisture content analysis

Moisture content was determined according to ASTM 871 for EFB-based MCC and commercial grade MCC powder.

Preparation of MCC tablets

About 500 mg of EFB-based MCC and commercial grade MCC powder were individually weighed and compressed using a compression machine (Instron, Model 5567) with a 7 kN force.

Physical properties of MCC tablets

Tests on tablet thickness, relaxation, disintegration, friability, hardness and tensile strength were conducted on the tablets. All analyses were done in triplicate.

Tablet thickness was determined using a micrometer screw gauge. The tablet was placed between the anvil and spindle of the screw gauge, and the thickness reading was recorded in millimeters.

For the relaxation test, the thickness of tablets was evaluated at time zero, and the tablets left overnight for 48 hr in air-tight containers at room temperature, following which the thickness of tablets was measured again. The changes in thickness were calculated in percentages using the

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following equation:

$$\% \text{ change in thickness} = 100 \times [(T_2 - 2T_1) T_1^{-1}] \%$$

where: T_1 is the initial value
 T_2 is the final value

The disintegration test was measured according to USP29/NF24 (<701> Disintegration) (USP, 2006a) using a digital tablet disintegrator, Copley DTG2000 IS.

Tablet friability is a measure of the weakness of the tablets. Generally, a limit not exceeding 1% is acceptable (USP, 2006b). Tablet friability (%) was determined according to USP29/NF24 (<1216> Tablet friability) by using a friability tester, Electrolab Friabilator USP (XXIII).

Hardness test and tensile strength analysis were done according to USP32/NF27 (<1217> Tablet breaking force) (USP, 2008a), using a universal testing machine (Instron 5567). Tensile strength (σ) (USP, 2008b) was calculated using following equation:

$$T = 2P (\pi dT)^{-1}$$

where:

P (N) is the load needed to break the tablet

d is the diameter (mm) of the tablet

T is the thickness (mm) of the tablet, and

$$\pi = 3.142.$$

RESULTS AND DISCUSSION

Approximately 37% cellulose (w/w) was extracted from the EFB fibre, of which 64.89% (w/w) of the cellulose was converted into MCC powder. The powder was sieved through a wire mesh of 63 μ m. The MCC powder that passed through the wire mesh was compressed into tablets (Figure 1).

Table 1 shows the physical and mechanical properties of EFB-based



(a) EFB-based MCC powder.



(b) EFB-based MCC tablets.

Figure 1. EFB-based MCC in different physical forms.

TABLE 1. PHYSICAL AND MECHANICAL PROPERTIES OF TABLETS PREPARED FROM EFB-BASED MCC AND COMMERCIAL GRADE MCC

Specification	EFB-based MCC	Commercial grade MCC
Moisture content (%)	5.89	5.72
Tablet thickness (mm)	3.56 \pm 0.027	3.58 \pm 0.039
Relaxation test (mm)	0.28 \pm 0.007	0.28 \pm 0.003
Disintegration test (min)	2.58	8.41
Friability test (%)	0.18	0.17
Hardness test (N)	23.7	22.8
Tensile strength (Nmm ⁻²)	3.44	3.16

MCC powder and commercial grade MCC. The moisture content of EFB-based MCC powder and commercial grade MCC was 5.89% and 5.72%, respectively.

The MCC powder was dried to 10% moisture content in order for it to act as a lubricant for determining the compatibility of the MCC structure (George, 2000). It was noted that the presence of moisture highly influences the compactness of the MCC tablets (Hammes *et al.*, 2016). The moisture content of EFB-based MCC powder was within the range of 5% to 10%, and therefore the powder is suitable for making direct compression tablets.

Characteristics of Compressed EFB-based MCC

Tablet thickness. EFB-based MCC and commercial MCC powders were compressed into tablet form under similar conditions. The thickness of the EFB-based MCC

tablets was 3.56 mm while those made from the commercial grade MCC was 3.58 mm thick. This indicates the compressibility of EFB-based MCC was comparable to commercial grade MCC in tablet making.

Tablet relaxation. From Table 1, the thickness of EFB-based MCC and commercial grade MCC tablets was increased by only 0.28% (or 0.01 mm) after they were stored in an enclosed container for 48 hr. The slight increase in thickness indicates that the samples were stable, and hence it would be unlikely for the tablets to suffer cracks.

Disintegration. The samples tended to disintegrate in less than 10 min after soaking them at 37°C. In contrast, the time taken for commercial grade MCC tablets to disintegrate was three times longer than that taken by the EFB-based MCC tablets. It is understood that the water absorbed by the tablet matrix causes MCC

particles to swell, resulting in tablet disintegration (Kalita, *et al.*, 2013; Lachman *et al.*, 1990).

Friability. The friability of EFB-based and commercial grade MCC tablets was 0.18% and 0.17%, respectively (Table 1). These results are within the range of the acceptable value, which is less than 1% (Bastos *et al.*, 2008).

Hardness. The hardness of EFB-based MCC tablets was 0.9 N, higher than the commercial grade MCC tablets (Table 1). At below 70 N hardness (Bastos *et al.*, 2008), the EFB-based MCC tablets tended to disintegrate within a short time. On the other hand, hardness also depends on the shape, chemical properties and pressure applied during compression (Fell and Newton, 1970), as well as the type of binding agent used (York and Pipel, 1973).

Tensile strength. Tensile strength of the EFB-based MCC tablets (3.44 N mm^{-2}) was higher than for commercial grade MCC tablets (3.16 N mm^{-2}). This may be due to the degree of dilution potential, water-holding capacity and the hydrogen bonding of MCC particles (Podczek and Al-Muti, 2010; Wang *et al.*, 2006; Sheth *et al.*, 1990; Lieberman *et al.*, 1989).

CONCLUSION

The properties of EFB-based MCC tablets were comparable to those of commercial grade MCC except for the time of disintegration. This indicates that the EFB-based MCC powder has potential as a filler and a binder in tablet formulations for the pharmaceutical industry.

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