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细菌纤维素水悬浮液的流变特性

Rheological properties of aqueous suspension of bacterial cellulose

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中文摘要:

为能更好地指导细菌纤维素作为增稠剂应用于食品工业，进一步了解细菌纤维素水悬浮液的流变学特性，该研究首先用原子力显微镜观察了细菌纤维素水悬浮液中纤维素的形态结构和直径，然后以羧甲基纤维素溶液为对照，分别从静态和动态2方面着手，用物性测定仪和流变仪测定细菌纤维素水悬浮液的稠度、黏性指数、剪切应力、表观黏度，剪切应力和表观黏度与剪切速率的关系等特性指标。分析了稠度、黏性指数、剪切应力、表观黏度与悬浮液中细菌纤维素质量分数的关系，比较了细菌纤维素水悬浮液与羧甲基纤维素溶液的差别，结果显示：细菌纤维素的直径为60～80 nm；细菌纤维素水悬浮液中的纤维素相互缠结，呈现散乱分布的网状结构，纤维素可聚集形成平行或螺旋状的纤维束；细菌纤维素水悬浮液在质量分数为0.4%～1.2%时的稠度和黏性指数远高于相同质量分数的羧甲基纤维素钠溶液，且与质量分数呈显著的正相关关系（P＜0.05, R2＞0.95）；在较低剪切速率0.02～10 s-1下，悬浮液的表观黏度随剪切速率的增加呈缓慢下降的趋势，出现剪切稀化现象；当剪切应力达到屈服应力时悬浮液才发生流动，且剪切应力与剪切速率呈正相关(P＜0.05, R2＞0.99)，流动特性指数为1，细菌纤维素悬浮液为非牛顿流体的宾汉塑性流体。因此细菌纤维素水悬浮液做为增稠剂应用于食品工业时具有宾汉塑性流体的特征。

英文摘要:

Abstract: With the application of bacterial cellulose in industry, the rheological properties of bacterial cellulose suspension, dissolved in heavy metals and organic solvents, have received extensive attention. However, heavy metals and some organic solvents can't be used in food, drug and cosmetic industry. Therefore, this study was aimed to investigate the rheological properties of bacterial cellulose suspension. Firstly, the surface morphology of bacterial cellulose was observed by atomic force microscopy (AFM). Secondly, the rheological properties of bacterial cellulose suspension were investigated by static and dynamic methods. Specifically, consistency and index of viscosity of bacterial cellulose suspension were determined by a Texture Analyzer (TA) with AB/E35 probe under static condition, and carboxymethyl cellulose(CMC) solution was used as a control. Furthermore, consistency and indexes of viscosity of these two kinds of suspension were compared in the present study. Additionally, the dynamic method was used to study the relationship of shear stress, apparent viscosity and shear rate with a rheometer. Finally, the stability of bacterial cellulose suspension and its improvement ways by centrifugation were studied in this paper. Results showed that the width of bacterial cellulose s was between 60-80 nm. The AFM imagines showed that the microfibrils were randomly arranged with plenty of spaces among them and some s may be gathered to form a parallel or spiral bundle. From the rheology analysis, it was found that the consistency and index of viscosity of bacterial cellulose suspension were significantly higher than those of carboxymethyl cellulose solution. Additionally, when the concentration changed from 0.4% to 1.2% a positive correlation was found between the consistency and viscosity index of bacterial cellulose suspension and the concentration of bacterial cellulose (P<0.05, R2>0.95). The equation between consistency and concentration of bacterial cellulose suspension was y=936.17x+38.166 (R2=0.9753). The equation between viscosity index and concentration of bacterial cellulose aqueous suspension was y=61.872x-21.641 (R2=0.9988). So bacterial cellulose s can be widely applied in food as thickening agent and dietary fiber, or paper and cosmetics industries as dispersing agent and binding agent. Under the condition of a relatively low shear rate(0.02-10 s-1), the apparent viscosity of bacterial cellulose suspension decreased with the increase of shear rate. On the contrary, under the condition of the same shear rate, the apparent viscosity and shear stress of bacterial cellulose suspension increased with the increase of concentration of bacterial cellulose suspension. The suspension displayed a shear-thinning behavior, so the bacterial cellulose suspension was called as non-Newtonian fluid. The suspension appeared to flow until the shear stress exceeds the yield stress and the values of shear stress were positively related to the values of shear rate (P<0.05, R2>0.99). So the bacterial cellulose suspension was called as Bingham plastic fluid. The stability of initial bacterial cellulose suspension was only 80%; however, when the CMC was added into the suspension, the stability of the bacterial cellulose suspension increased a lot. In addition, when the concentration of CMC was about 0.5%, the stability of bacterial cellulose suspension increased to about 95%. Therefore, CMC can improve the stability of bacterial cellulose suspension.

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