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The effect of carboxymenthyl cellulose in PP fibers for dye absorption ability

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Abstract

The present study aims to the use of carboxymenthyl cellulose (CMC) improving the ability of fiber in the dyeing process. Cellulose was extracted from banana leaves by NaOH and then modified by reacting with chloroacetic acid to obtain the carboxymenthyl cellulose. The effect of carboxymenthyl cellulose contents on the mechanical properties and dye absorption were also investigated. Then, CMC were blend with polypropylene (grade 561R) at 1%, 3% and 5% by weight ratio. The fibers were obtained from single screw extruder. The results show that the mechanical properties of the product decreased when increased the amount of CMC in the fiber product. After dyeing, the dye however were absorbed by the CMC-PP fibers more than the original PP fibers. The absorption of dye on the CMC-PP fibers increased significantly with the CMC ratio.

***Keywords**: Banana leaves, carboxymenthyl cellulose, PP fiber and dyeing*

1. INTRODUCTION

In search of new polymeric materials from nature, the carboxymethyl cellulose (CMC) have been focus due to its can be synthesised from verities of the plants waste such as papaya peel,[1] palm kernel cake,[2] and durian rind,[3] waste of mulberry paper,[4] banana leaves as an alternative materials. CMC is a derivative of cellulose and formed by its reaction with sodium hydroxide and chloroacetic acid. It has a number of sodium carboxymethyl groups (CH_2COONa), introduced into the cellulose molecule, which promote water solubility. The three parameters that control the various properties of CMC are as follows; molecular weight of the polymer, average number of carboxyl content per anhydroglucose unit, and the distribution of carboxylmethyl group substituents along the polymer chains[5-7]

During the past few years, many researchers have paid considerable attention to the study of carboxymethyl cellulose due to this material is an important industrial polymer which give a wide range of

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applications such as drag reduction, detergents, textiles, paper, foods, adhesives, paints, pharmaceutics, and oil well drilling operation.[8-15] In textiles industrial, CMC is used in the printing paste as a thickener and a emulsifier which significantly improve the vividness of printing, and improve the stability of the color paste.[16]

Polypropylene (PP) is one of the most widely used synthetic fibers in textile industry, which is cheaper and stronger than the other synthetic fibers. Beside, PP can be used in various applications, for example, film, package, cover stock, cable, napkin, and so on. Particularly, it is used for carpet, automotive interior trim and etc.[17, 18] However, PP fibers traditionally has limited their adoption in textile apparel applications. In the dyeing process, PP fibers are difficult to dye. Thus, the color has to be imparted at the fiber extrusion step through mass coloration or solution dyeing.[19, 20] Then the products made up of PP need color absorption activity, one of the important functionalities, than the others.

Many researchers have tried to transform this banana leaves into a valuable product. However, very little has been published on the utilization of banana leaves. To date, no research has presented the CMC from banana leaves and blend with polypropylene to make fibers. In this study, the effect of CMC in CMC/PP fibers composite on the dying process was also investigated.

2. EXPERIMENT

2.1 Materials

The polypropylene grade 561R was purchased from HMC Polymer Company limited. The commercial carboxymethyl cellulose (CMC_c) was supplied by Chemipan Thai Co., Ltd. Glycerol, Sodium hydroxide, ethanol, Isoproparol, monochloroacetic acid, hydrochloric acid were purchased from Sigma Aldrich. Dianix Red 2BSL-FS 150 was supplied by Hoechst Thai co., Ltd. All other chemicals were used as supplied by the companies.

2.2 Preparation of CMC/PP composite

The synthesis of CMC was slightly modified according to Rachtanapun et.al.[1] The PP pellets were dried at 80℃ overnight prior to compounding. The 1000g of PP pellets was mixed with 1% 3% and 5%wt CMC. The glycerol 4 drop was added into the mixture. The CMC was blended with PP using ThermoHake PolyDrive (Single Screw Extruder). The extruder barrel-temperatures from zone 1 to zone 5 were set 160℃, 170℃, 180℃, 190℃ and 190℃, respectively. The screw speed was 40 rpm. The obtained CMC/PP composites were passed through 5mm die and cut into pellet size.

2.3 Preparation of CMC/PP composite fibers by melt spinning technique

The CMC/PP composite pellets were mixed using ThermoHake PolyDrive. The barrel-temperatures from zone 1 to zone 5 were operated 175℃, 180℃, 185℃, 190℃ and 195℃, respectively. The screw speed was 40 rpm. The molten polymer then passes through the spinneret which have 5 hole of 2.5 millimeters (1 hole=0.5 millimeters). The melting composite exit from the spinneret was drawn down 2 times into the fibers shape.

2.4 Fiber Dying

The dye solution was prepared by dissolving 0.04gm of the dye, Dianix Red 2BSL-FS 150, in water 5mL. After completely dissolve, 80mL of water was added into the solution to form the dye solution. The fibers were dyed by dipping the 2gm of fiber into the dye solution and then the solution temperature was raised to

95-98℃ and hold for 30 mins. After that the fibers was washed twice in 80 mL of water and dried at 80℃ in oven for 8 hrs.

3. CHARACTERISATION

3.1 Fourier transform infared (FTIR)

The FTIR measurement were conducted using Thermo Nexus Nicolet 470 at the resolution 4cm^{-1} in wave number region 4000-400cm^{-1}. The cellulose and CMC were mixed with KBr into a disk. The fiber composite were compressed into a film.

3.2 Scanning electron microscope (SEM)

The SEM images were recorded by using Jeol JSM-6510. The surface fracture of the fibers were prepared by dipping the fibers into a liquid nitrogen and then break its. The fibers were stuck on the stub using carbon tape. The fibers were coated with Pt.

3.3 Tensile strength

The tensile strength or tenacity of the fibers were recorded using Instron 5560 universal testing machine. The speed of the cross head was 30mm/mm.

4. RESULTS AND DISCUSSIONS

4.1 Characterization of CMC_b

The synthesis of CMC was slightly modified according to Rachtanapun et.al.[1] The CMC prepared from banana leaves (CMC_b) presents an ivory powder while the commercial CMC (CMC_c) is a white powder, as shown in the Figure 1. The functional-group of the CMC was determined using the Fourier Transform Infrared spectroscopy (FTIR). The FTIR spectrum of CMC_b and CMC_c were shown in Figure 2. The stretching vibration of COO- were presented at 1580 cm^{-1}. The absorbance at 1412 cm^{-1} and 1322 cm^{-1} is ascribed to CH_2 and CH stretching vibration, respectively. The >CH2-O-C stretching vibration is at 1058 cm^{-1}.[21] This FT-IR spectrum confirmed that the CMC_b is a carboxymethyl cellulose.

Figure 1. (a) commercial CMC (CMC_c) powder and (b) synthesis CMC_b powder.

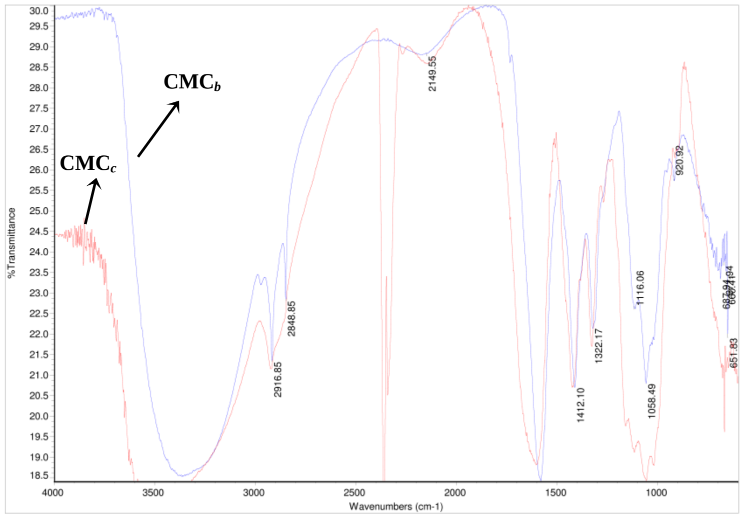

Figure 2. FT-IR spectrum of synthesis CMC powder and commercial CMC powder.

3.2 Characterization of CMC/PP fibers composite

3.2.1 Fourier Transform Infared spectroscopy (FTIR)

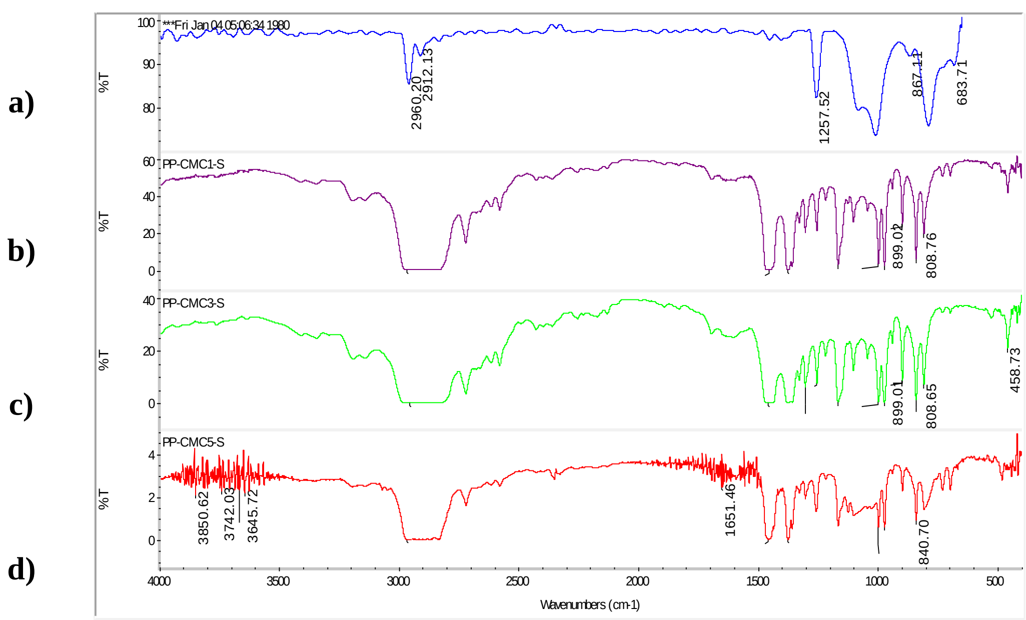

Figure 3. FT-IR spectra of PP (a), PP+1%wtCMC$_b$(b), PP+3%wtCMC$_b$ (c), and PP+5%wtCMC$_b$(d).

The Fourier Transform Infared spectroscopy (FTIR) of CMC/PP fibers were illustrated in Figure 3. The FTIR spectrum of polypropylene, shown in Figure 3(a), indicates a shoulder at 2960 cm^{-1}, and the asymmetric and symmetric in-plane C–H (–CH_3) at 1455 and 1257 (shoulder) confirm polypropylene. The results shown that the functional groups of carboxymethyl cellulose present at 1456 cm^{-1}, 1456 cm^{-1}, 1374

cm^{-1}, 1058 cm^{-1} were found in Figure3 (b-d).[21] The intensity of FT-IR spectrum of those peaks increased by the content of CMC_b in fibers. The broaden spectrum was found at 2960 cm^{-1} when CMC_b was blended with PP which respect to the content of CMC_b in the fibers. This FT-IR spectrum confirmed that the CMC_b is well blended with PP.

3.2.2 Scaning Electron Microscope (SEM)

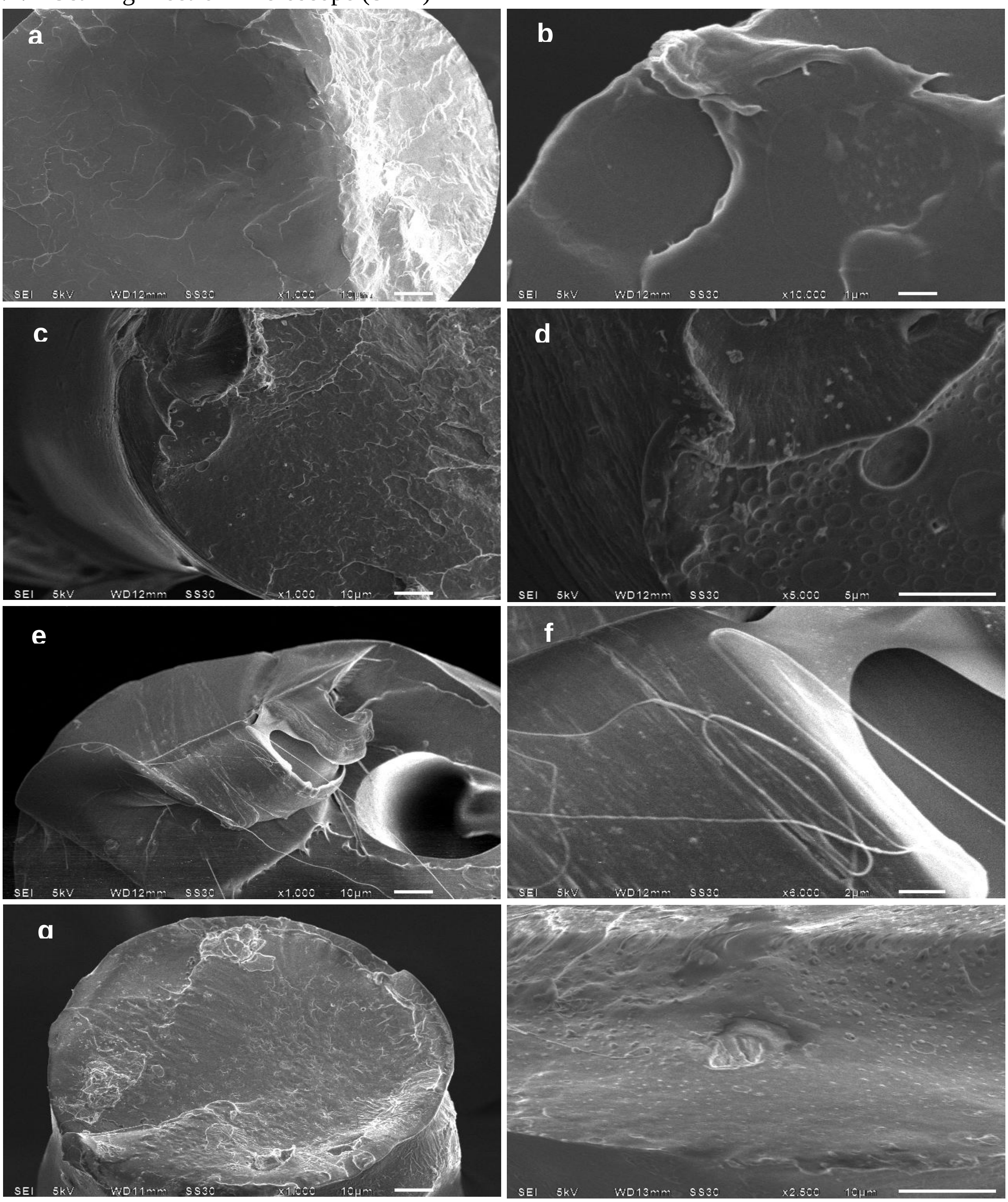

Figure 4. SEM images of PP (a and b) PP+1%CMC$_b$ (c and d) PP+3%CMC$_b$ (e and f) and PP+5%CMC$_b$ (g and h)

The fracture surface of the CMC_b/PP fibers composite at different ratio of CMC_b from 1%wt of CMC_b to 5%wt of CMC_b were investigated using Scaning Electron Microscope (SEM), as seen in Figure 4(a-h). It was noticed that the amount of CMC_b in the PP fibers composite increased when raising the amount of CMC_b from 1%wt of CMC_b to 5%wt of CMC_b, as shown in Figure 4(c-h). The fracture surface of the PP is smooth, as presented in Figure 4 (a-b). Figure 5h presented the well define dispersion of CMC_b in the CMC/PP fibers containing 5%wt CMC_b. In the SEM micrographs, it is demonstrated that the CMC_b powder consists of uniform spherical microparticles, but some particles are aggregated by interaction force of micro-CMC_b powder.

3.2.3 Tenacity Test

The tensile properties of the CMC/PP fibers containing 1%wt, 3%wt and 5%wt of CMC was test using Instron 5560 Universal Testing Machine. The results of the tenacity test were shown in Figure 5. It was found that the tenacity of CMC/PP fibers composite containing 1%wt and 3wt% in both of CMC_c and CMC_b were very similar and decreased about 45% compare to the tenacity of PP. However, the tenacity of CMC/PP fiber composite containing 5%wt of CMC_c and CMC_b were lowest at 0.05 gf/den and 0.043 gf/den, respectively.

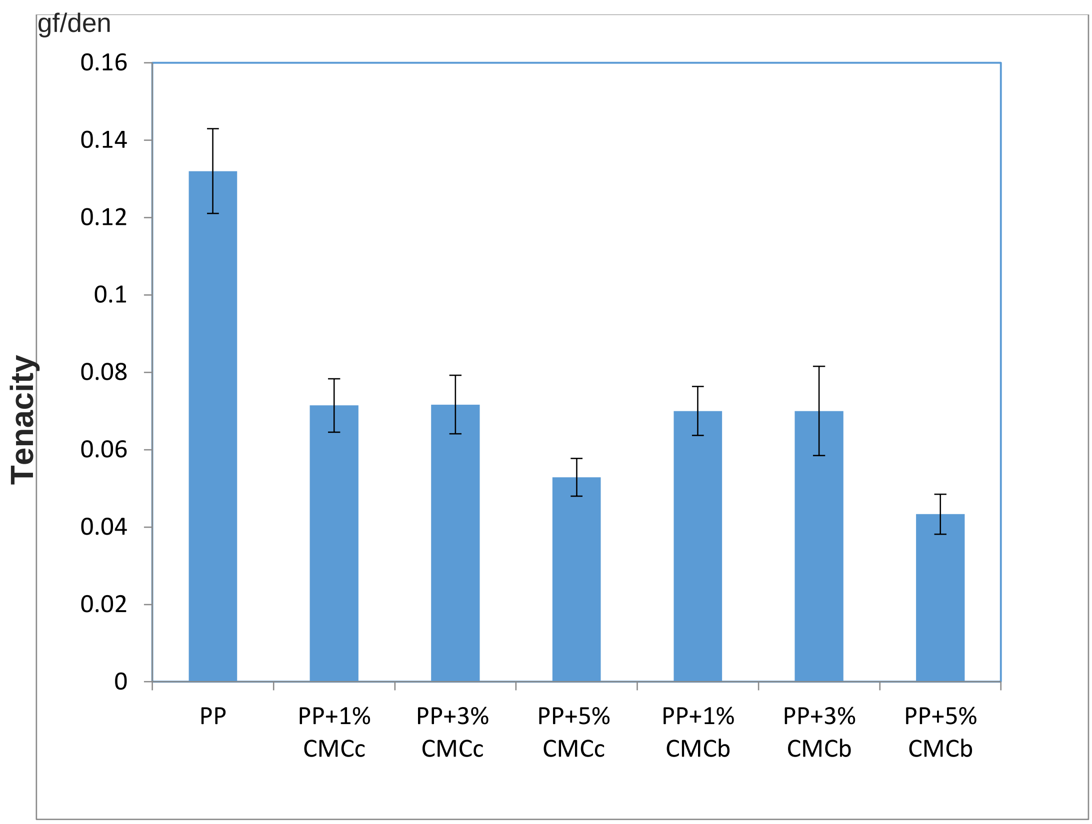

Figure 5. Tenacity of PP fiber, PP fiber composite containing 1%wt, 3%wt and 5%wt of CMC_c and CMC_b.

3.2.4 Fiber Dying

The fiber was dyeing using the red dye, Dianix Red 2BSL-FS 150. The PP fiber was used as a control. The CMC/PP fibers containing 1%wt and 3%wt of both CMC_c and CMC_b give the similar color, as seen in Figure 5(2B-2C and 3B-3C). On the other hand, the CMC/PP containing 5%wt of both CMC_c and CMC_b provide light red color than the fiber containing 1%wt and 3%wt of CMC, as presented in Figure 6(4B-4C). The absorption of the dye on the PP fiber, Figure 6(1B-1C), are lowest compare to the all of the CMC/PP fiber composite.

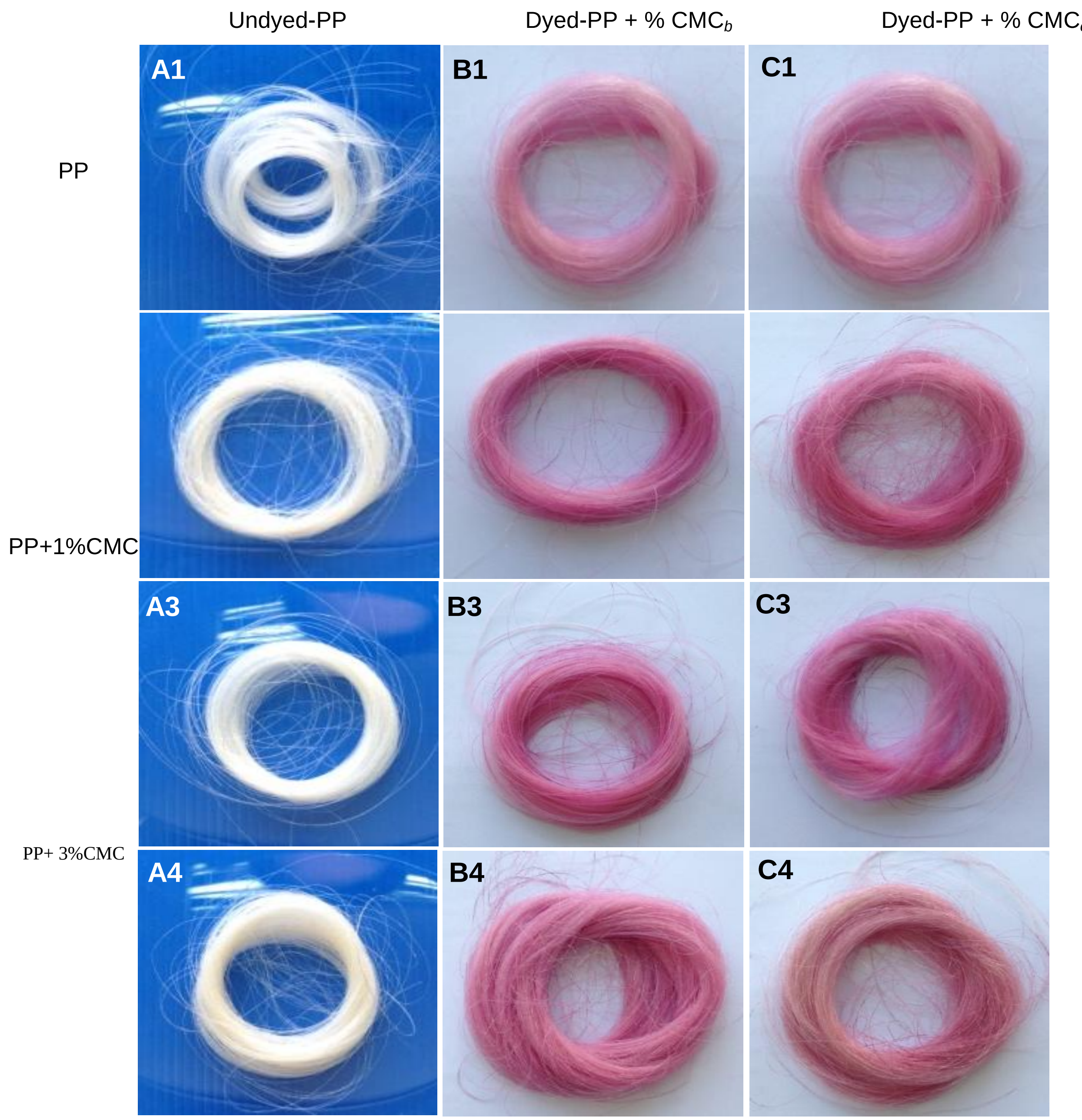

Figure 6. The photography of undyed and dyed for PP, PP+CMC_c 1%, PP+CMC_c 3%, PP+CMC_c 5%, PP+CMC_b 1%, PP+CMC_b 3% and PP+CMC_b 5%

4. CONCLUSION

The aim of this study was to prove the effect of carboxymethlyl cellulose in CMC/PP fibers composite which synthesis from banana leaves by various techniques. Variation of the carboxymethlyl cellulose content in the PP fibers composite resulted in a dye absorption of the fibers. With increase in the amount of carboxymethlyl cellulose of PP fibers composite, the dye absorption of the PP fibers composite gradually increase. The FTIR spectra of the CMC_b/PP fibers composite also provide proof of well blending. SEM micrographs show the fracture surface of the PP-CMC_b fibers composite at different ratio. The tensile properties of the CMC/PP fibers results provide further evident to proof that this fibers composite able to make a textile products.

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