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Effect of Organic Alternative Mercerization Agents on Structure of Cellulose/Polyester Blend Fabric

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Abstract This study investigates the effect of organic alternative mercerizing agents on structure of cellulose/polyester blend fabric. A structural modification for a cellulose/polyester blend has been carried out using $(COOH)_2$, CH_3COOH and CH_3CH_2OH alternative mercerizing agents and NaOH was used as control. The mercerized fabrics were then subjected to structural analysis using X-ray diffraction in order to expose the possible modifications on the pretreated fabrics. The samples showed possibilities of being highly competitive with the conventional agent. These inferences were drawn from the difference in the crystallinity index of mercerized samples (40.22 – 53.84%), the crystallite size of mercerized samples (0.342 – 0.345nm) in the crystalline region, in the amorphous region, inter-planar spacing of the mercerized samples (0.342 – 0.345nm) of the crystalline region and (0.360-0.390 nm) of the amorphous region of sample and number of crystalline planes of the mercerized sample is (7.0 – 10.0) of the cellulose/polyester blend fabric samples via X-ray diffraction studies.

Keywords Fabrics, Mecerization, Crystalline region, Polyester, Armorphus

Introduction

The recent development and changes in life style in the world has attracted people towards a safer, cheaper and fast textile product. Today, everyone needs better quality fabric products with improved performance at an affordable rate [1]. This can only be achieved by improving the performance of these products, by looking for alternative processes/reagents that give better results [2]. Several researches such as Barambu *et al.*, [3] and Boryo *et al.*, [4] have been done in order to modify fabric to meet the requirement for the rapid development in the fashion desires of the world. The mercerization process consists of treatment of bleached textile materials with concentrated solutions of caustic soda at a temperature 5°C. Mercerized cellulose is hydrated cellulose, i.e., a product which from the chemical point of view is identical to the original cellulose, but differing from it in physical properties [5]. During mercerization, selective bonding of sodium to cellulose takes place [6]. This reaction is as shown below.

$C_6H_7O_2(OH)_3 + 3NaOH \longrightarrow C_6H_7O_2(ONa)_3 + 3H_2O$

Formation of Trisodium Cellulose (Alcoholate):

Source: (Sadov*et al.*, [7])

This work investigated structural modification changes on cellulose/polyester blend fabrics by the organic alternative mercerizing agents and subjected to structural analysis using X-ray diffraction in order to elucidate the possible modifications on the structures of the pretreated fabrics. In line with increasing demand for highly valued

cheap fabrics and environmentally friendly processes, this research will meet the specification and aspirations of the textile industries and also establishes and authenticate the numerous advantages of the alternative agents by textile industries.

Materials and Methods

The sample of 35%/65% cellulose/polyester blend fabric was purchased from Central Market Bauchi, Bauchi State, Nigeria. The sample was cut into pieces of dimension 10 cm length by 10 cm width and kept in the laboratory prior to chemical treatment. The cellulose/polyester blend fabrics was scoured, bleached and mercerized according to standard methods of (Sadov *et al.*, [7]; and Boryo, [8]).

Mercerization Process (Alternative Mercerizing Agent)

In this study a mercerizing process adopted by Boryo, [8], Boryo *et al* [9] and Boryo *et al.*, [10] was used. The bleached samples were mercerized in separate beakers of 19%, 20%, 21%, 22% and 23% NaOH solution as control. The mercerization was carried out for 45 minutes at below 5^{o}C. The samples were rinsed, neutralized (with 5% CH_3COOH), washed in detergent solution, rinsed and dried in the laboratory. The procedure was repeated for 19 – 23%, oxalic acid $(COOH)_2$, acetic acid $CH_3COOH$and ethanol (CH_3CH_2OH), as alternative mercerizing agents.

Result and Discussion

Effect of Organic Alternative Mercerizing Agents on Crystallinity Index

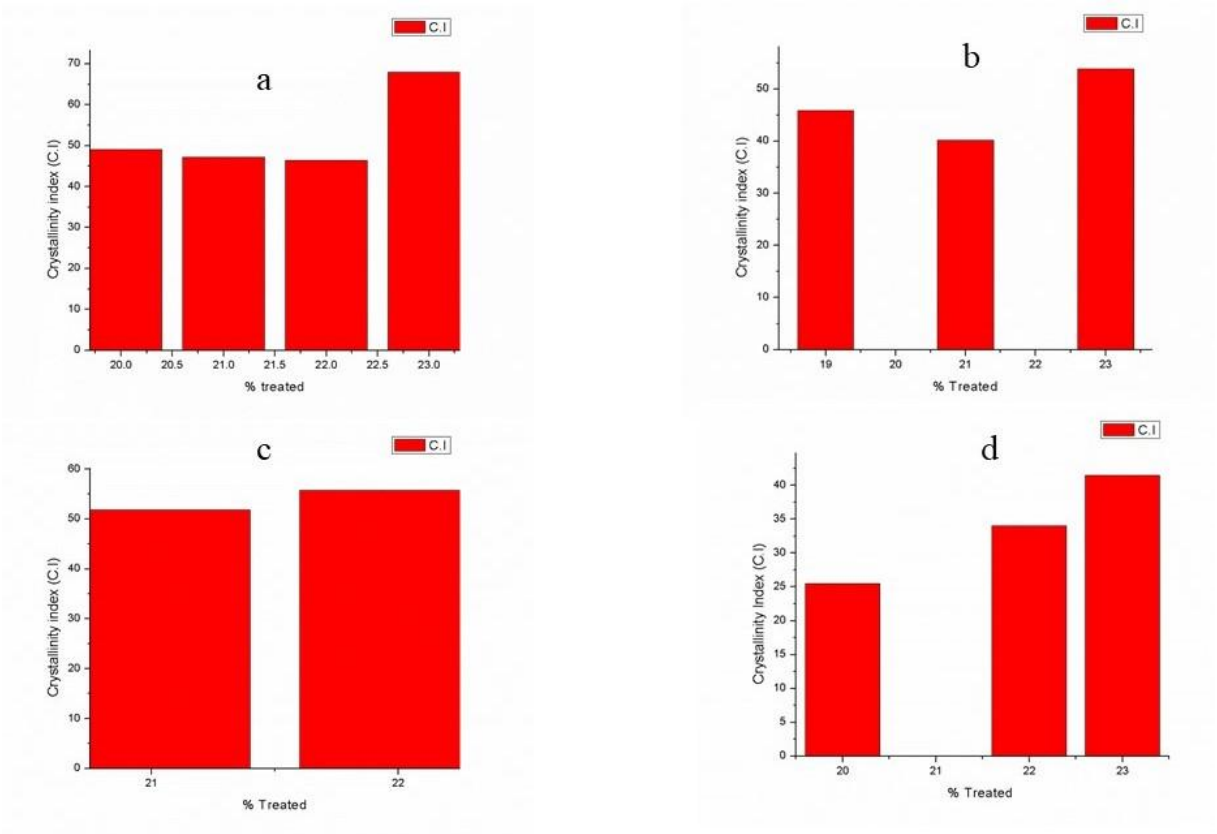

Figure 1: Percentage crystallinity index for (a) NaOH, (b) CH_3COOH, (c) $(COOH)_2$, and (d) CH_3CH_2OH cellulose/polyester blend fabric.

Mercerization of Cellulose/Polyester blend fabric with CH_3COOH showed increase in crystallinity index (40.22 – 53.84%) despite the low temperature employed which could not permit the hydrolysis of the amorphous region. Increase in crystallinity index suggested that the use of CH_3COOH in mercerization of cellulose/polyester blend

fabric could bring about the desired lustrous appearance with improvement in the mechanical strength. The crystallinity index (51.87 – 55.74%) of cellulose/polyester blend fabric samples mercerized with $(COOH)_2$ increased well above that of the untreated sample (Figure 1c) indicating possible modification of the structure of the sample as hydrolysis could not proceed significantly at low temperature used for the mercerization process. This result suggested that cellulose/polyester blend fabric mercerized with $(COOH)_2$ might possess good dyeing properties as well as improved mechanical properties as the crystallinity index of the cellulose/polyester blend treated was increased [10].

Mercerized Samples with different wt.% of CH_3CH_2OH showed reduced crystallinity index (25.47 – 41.46%) compared to the untreated sample. This indicated that cold CH_3CH_2OH was able to diffuse into the crystalline and amorphous regions of the polyester blend, which could only result in morphological transformation of the fabric sample. Although the crystallinity index was low, it was well above that observed in samples treated with liquid NH_3.

Effect of Organic Alternative Mercerizing Agents on d-spacing

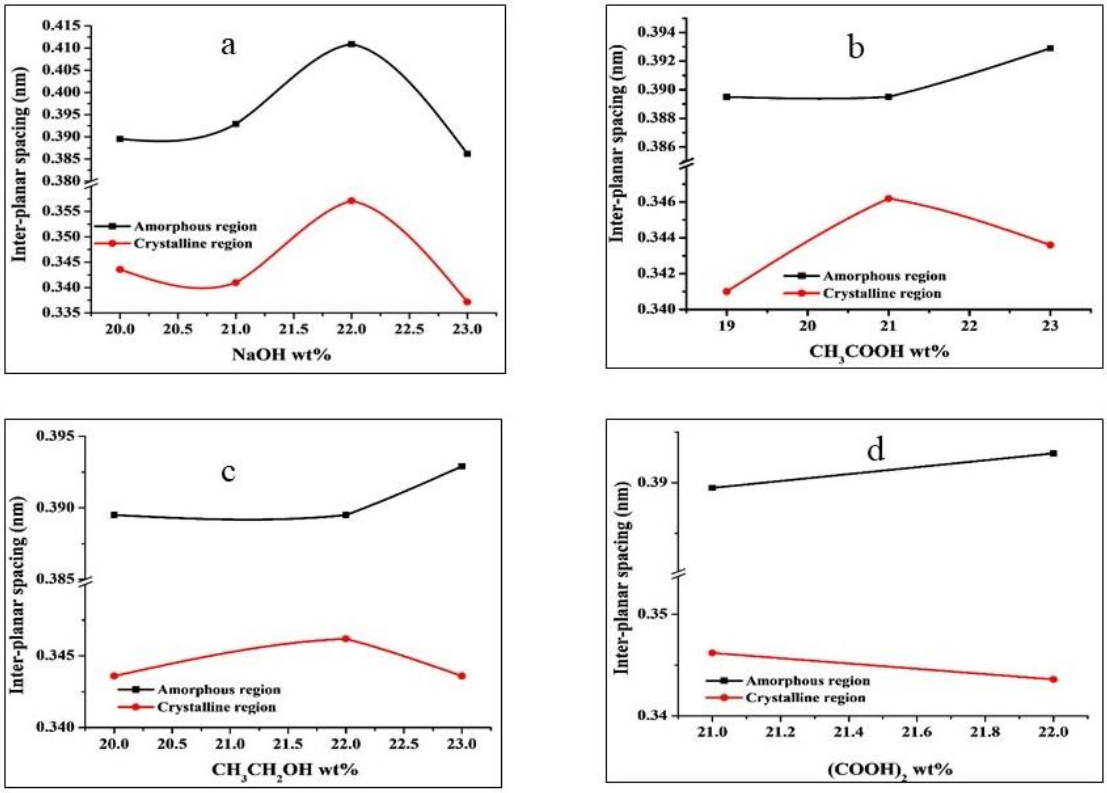

Figure 2: The inter-planar spacing (d-spacing) for (a) NaOH, (b) CH_3COOH, (c) $(COOH)_2$, and (d) CH_3CH_2OH cellulose/polyester blend fabric

The variation in the inter-planar spacing in both crystalline and amorphous regions was quite low in (Figure 2b). The inter-planar spacing of both amorphous and crystalline regions (0.342 – 0.345nm) showed no significant difference with increase $(COOH)_2$ employed. $(COOH)_2$ was able to interact with both amorphous and crystalline regions. The inter-planar spacing of amorphous and crystalline regions varied slightly in (Figure 2c) this would definitely impact on the mechanical and dyeing properties of the fabric.

Effect of Organic Alternative Mercerizing Agents on Crystallite Size

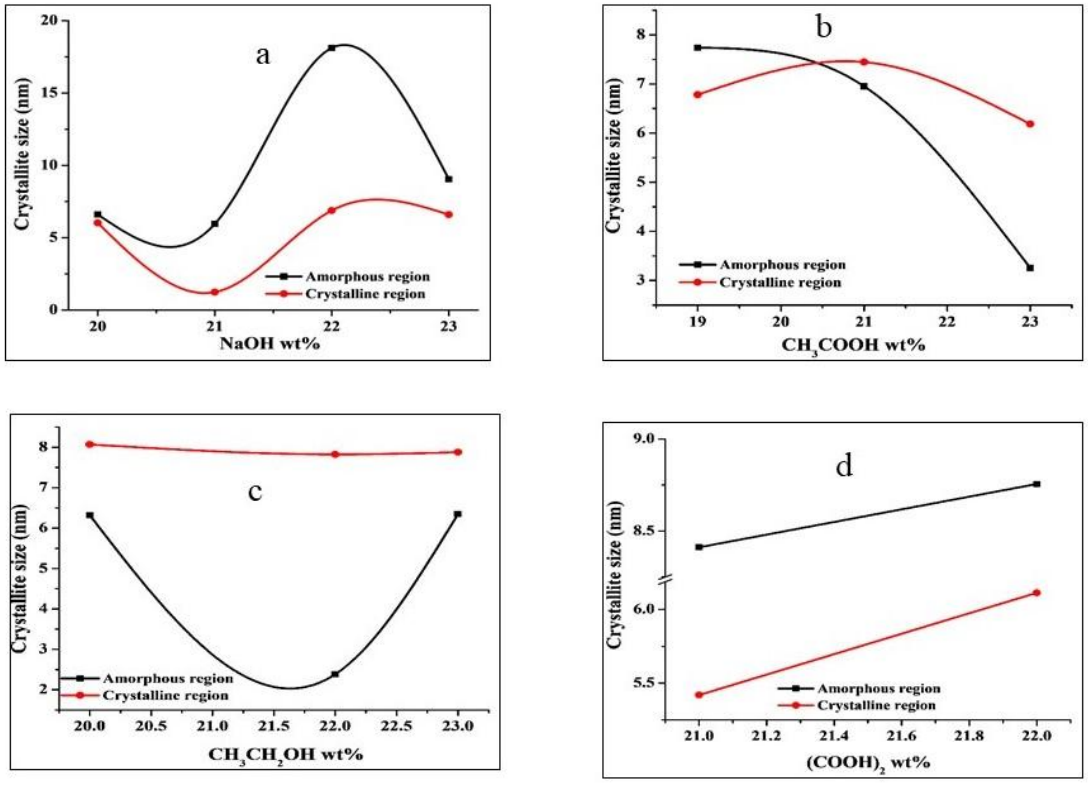

Figure 3: The Crystallite size for (a) NaOH, (b) CH_3COOH, (c) $(COOH)_2$, and (d) CH_3CH_2OH cellulose/polyester blend fabric.

The crystallite size of the amorphous region decrease with increase in concentration of CH_3COOH used in the mercerizing process, the crystallite size of the crystalline region (40.22 – 53.84%) increase. This could also be attributed to flexibility with which the amorphous region of the cellulose/polyester blend fabric could be easily mercerized with CH_3COOH. The result showed that CH_3COOH could be a competing alternative mercerizing agent with NaOH as reported by Boryo *et al.,* [10]. $(COOH)_2$ was able to interact with both amorphous and crystalline regions as shown by the variation in crystallite sizes observed in both regions. The crystallite sizes in the crystalline planes increased to approximately 8 nm from about 2nm in untreated samples. However, the crystallite sizes of the amorphous region reduced from about 13 nm in the untreated sample to approximately 2 nm in sample mercerized with 22 wt.% of CH_3CH_2OH while it was about 6 nm in samples mercerized with 20 and 23 wt.% CH_3CH_2OH. This showed that the interaction of CH_3CH_2OH in mercerization of cellulose/polyester blend fabric sample was more uniform in the crystalline region than amorphous region. This would definitely impact on the mechanical and dyeing properties of the fabric [10].

Effect of Organic Alternative Mercerizing Agents on number of crystalline planes

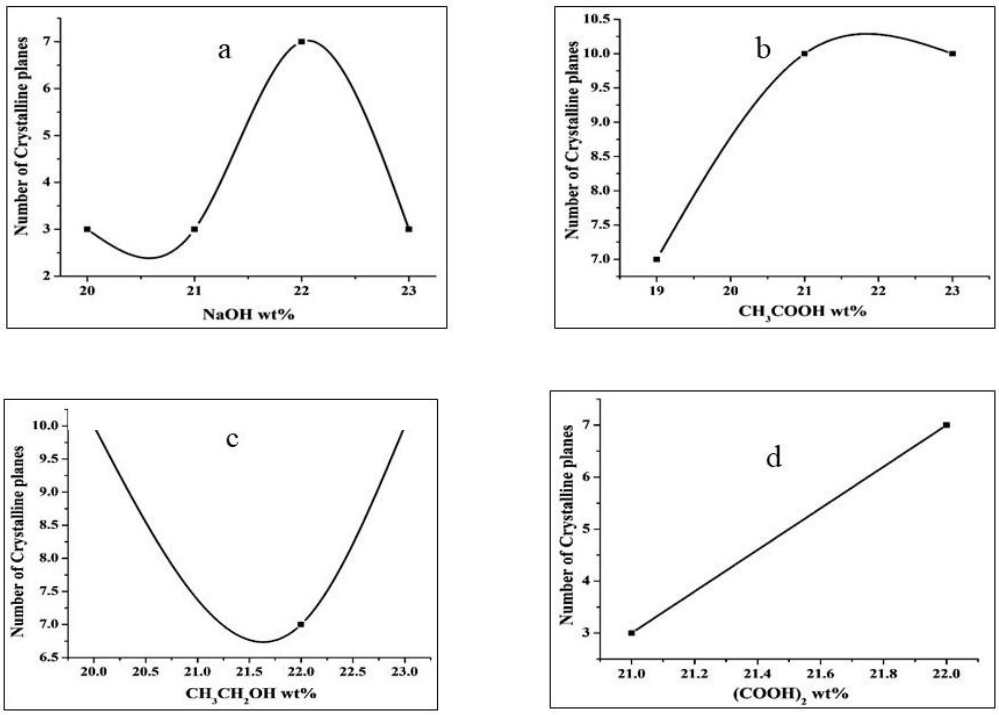

Figure 4: The number of crystalline planes for (a) NaOH, (b) CH_3COOH, (c) $(COOH)_2$, and (d) CH_3CH_2OH cellulose/polyester blend fabric.

This showed that the interaction of CH_3COOH with the sample could only result in structural modification which could be inferred by the variation in number of crystalline planes (7.0 – 10.0) with increase in wt.% of CH_3COOH used. The implication of this result would be that CH_3COOH was able to diffuse into the fabric without necessarily degrading it via hydrolysis. The difference in number of crystalline planes (3.0-7.0) of $(COOH)_2$ observed also suggested structural modification. The possibility of occurrence of morphological transition in the sample based on interaction of cold CH_3CH_2OH used in the mercerization was further buttressed by the emergence of several crystalline planes (7.0 – 10.0) that were not present in the untreated sample.

Conclusion

Mercerization of cellulose/polyester blend fabric using alternative agents was carried out and the effect on the structures of the fabric ware evaluated using X-ray diffraction. Also the property-structure relationship between the alternative scouring and mercerizing agents on the fabric ware determined. It was confirmed that the modifications on the fabric were both physical and chemical changes.

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