# INFLUENCE OF ALKALI TREATMENTS ON THE MOISTURE PROPERTIES OF NIGERIAN SISAL FIBRE

**[1]E.S. Nwadiokwu, [2]O.K. Sunmonu and [3]K.O. Fashola**

**[1]Chemical, Fibre and Environmental Technology Department, Federal Institute of Industrial Research Oshodi, P.M.B. 21023, Ikeja, Lagos, Nigeria**

**[2]Department of Polymer and Textile Technology, Ahmadu Bello University, Zaria, Nigeria**

**[3]Department of Polymer and Textile Technology, Ahmadu Bello University, Zaria, Nigeria**

Corresponding author email: esnwadiokwu@gmail.com

**ABSTRACT**

The influence of alkali modification on the moisture properties of Nigerian sisal fibres has been studied. The sisal fibres were chemically modified using different concentrations of caustic soda (5%, 10%, 15% and 20%) while varying the treatment time (5mins, 10mins and 15mins). Treated and untreated samples were investigated for their moisture properties. The moisture regain and moisture content of the fibres were substantially influenced by the alkali treatments which increased with increasing concentration at constant time. The increase in time of treatment at constant concentration had no significant effect on the moisture properties investigated.

## 1.0 INTRODUCTION

Sisal fibre is a hard fibre extracted from the leaves of sisal plant (*Agave sisalana*). Though native to tropical and subtropical North and South America, sisal plants are widely grown in tropical countries of Africa, the West Indies and the Far East (Bisanda *et al.,* 1994). Tanzania and Brazil are the two main producing countries (Chand *et al*, 1998).

Using sisal fibre as reinforcement in composites has raised great interest and expectations among material scientists and engineers (Bledzki *et al*, 1996). However, sisal fibre reinforced composites generally have poor interface (Bledzki *et al*, 1999). Moisture properties of sisal fibres determine to a large extent the nature of the fibre surface and the surrounding matrix.

Several fibre surface treatment methods have been studied to improve the adhesion properties between sisal fibres and a surrounding matrix. An effective method includes alkali treatment to improve the moisture properties of fibre.

In this research, alkali treatment was employed to chemically modify sisal fibres using different concentrations of NaOH (5%, 10%, 15% and 20%) and at different time (5mins, 10mins and 15mins). The effects of this modification on the moisture properties were assessed and analyzed.

## 2.0 MATERIALS AND METHOD

### 2.1 Materials

The main materials for this study are sisal fibres obtained from the Botanical garden of the Ahmadu Bello University, Zaria.

### 2.2 Chemicals

Aqueous sodium hydroxide solution (5, 10, 15 and 20% by weight) and acetic acid (2% by weight).

### 2.3 METHOD

#### 2.3.1 Extraction of the Sisal Fibres

The leaves were crushed and beaten manually by a smooth edged stick so that only fibres remain. After extraction, the fibres were washed thoroughly in plenty of water to remove surplus wastes such as chlorophyll, leaf juices and adhesive solids (hemicelluloses). The fibres were then dried in open air. Dried sisal fibre strands are usually creamy white in colour.

#### 2.3.2 Chemical Modification of the Fibres

2 grams of the sisal fibres were soaked in 5, 10, 15 and 20% NaOH solution for 5, 10 and 15 minutes at a temperature of $65^0$C. These fibres were further rinsed with water followed by

neutralization in 2% acetic acid solution. A final rinse in water and then dried at room temperature.

Sisal–OH + NaOH → Sisal–$O^-Na^+$ + $H_2O$

### 2.3.3 Determination of Moisture Content and Moisture Regain

The sisal fibres were weighed and dried in an oven at a temperature of 103°C for 30 minutes, followed by cooling for 30 minutes and then weighed again. This step was repeated until the weight was constant. The moisture regain of the test specimen was expressed as a percentage loss in weight of the final oven-dry weight using the following equation;

$$\text{Moisture Content} = \frac{W_0 - W_1}{W_1} \times 100\ (\%)$$

Where Wo is the weight of fibre before dried in oven and W1 is weight of fibre after dried in oven. Also moisture regain was calculated using the following formula (Booth J.E, 1968);

$$R = \frac{M}{1 + \left[\frac{M}{100}\right]}$$

Where R =Moisture regain
M=Moisture content

The effects of concentration and time on the moisture regain and moisture content were determined for both the modified and unmodified sisal fibres. Ten tests were carried out and the mean values are reported in table 1.

## 3.0 RESULTS AND DISCUSSION

### 3.1 Moisture Content and Regain

Usually, alkali modification causes appreciable changes in the moisture absorption for all sisal fibres. Modified sisal has higher regain compared to the unmodified ones. It can be seen from table 1 that increases in the concentration of NaOH at constant time, increases the moisture content and regain as compared to the unmodified fibre.

This increase may be due to the fact that increase in concentration of NaOH, increases the accessible surface of the sisal fibre due to increase in the amorphous region owing to the swelling of the fibres. Moreover, alkali treatment increases the number of possible reactive sites and allows better fibre wetting.

The effect of alkali on sisal fibres is a swelling reaction, during which the natural crystalline structure of the cellulose relaxes. Native cellulose shows a monocyclic crystalline lattice of cellulose I which can be changed into different polymeric forms through chemical treatments.

Increase in the concentration of alkali will influence the degree of swelling and hence the degree of lattice formation into cellulose II (Fengel and Wengener, 1983).

Studies have shown that $Na^+$ has got a favourable diameter, able to widen the smallest pores in between the lattice planes and penetrates into them. Consequently, NaOH treatment results to higher degree of swelling (Wenyenberg *et al.*, 2006).

However, increase in time of treatment at constant concentration does not have much effect on the moisture properties as shown in table 2.

**Table 1. Moisture content and regain for sisal fibres at different concentrations and at constant time.**

| | Moisture Content (%) | Moisture Regain (%) | Standard deviation | C V (%) |
|---|---|---|---|---|
| **Untreated** | 7.90 | 8.80 | 0.51 | 5.79 |
| **5%for5mins** | 10.15 | 11.30 | 0.56 | 4.96 |
| **10%for5mins** | 10.95 | 12.10 | 0.59 | 4.88 |
| **15%for5mins** | 11.89 | 13.09 | 0.62 | 4.73 |
| **20%for5mins** | 12.90 | 14.10 | 0.62 | 4.16 |
| **5%for10mins** | 10.60 | 11.86 | 0.57 | 4.80 |
| **10%for10mins** | 11.76 | 12.95 | 0.59 | 4.56 |
| **15%for10mins** | 12.78 | 14.03 | 0.60 | 4.28 |
| **20%for10mins** | 13.68 | 14.90 | 0.61 | 4.09 |
| **5%for15mins** | 11.58 | 12.55 | 0.57 | 4.62 |
| **10%for15mins** | 12.64 | 13.06 | 0.59 | 4.51 |
| **15%for15mins** | 13.73 | 14.08 | 0.60 | 4.26 |
| **20%for15mins** | 14.53 | 15.81 | 0.62 | 3.92 |

**Table 2 Showing Moisture content and regain for sisal fibres at constant concentration and at different times.**

| | Moisture Content (%) | Moisture Regain (%) | Standard deviation | C V (%) |
|---|---|---|---|---|
| **Untreated** | 7.90 | 8.80 | 0.51 | 5.79 |
| **5%for5mins** | 10.15 | 11.30 | 0.56 | 4.96 |
| **5%for10mins** | 10.60 | 11.86 | 0.57 | 4.80 |
| **5%for15mins** | 11.58 | 12.55 | 0.57 | 4.62 |
| **10%for5mins** | 10.95 | 12.10 | 0.59 | 4.88 |
| **10%for10mins** | 11.76 | 12.95 | 0.59 | 4.56 |
| **10%for15mins** | 12.64 | 13.06 | 0.59 | 4.51 |
| **15%for5mins** | 11.89 | 13.09 | 0.62 | 4.73 |
| **15%for10mins** | 12.78 | 14.03 | 0.60 | 4.28 |
| **15%for15mins** | 13.73 | 14.08 | 0.60 | 4.26 |
| **20%for5mins** | 12.90 | 14.10 | 0.62 | 4.16 |
| **20%for10mins** | 13.68 | 14.90 | 0.61 | 4.09 |
| **20%for15mins** | 14.53 | 15.81 | 0.62 | 3.92 |

## CONCLUSION

Treated and untreated samples were investigated for their moisture properties. The moisture regain and moisture content of the fibres were substantially influenced by the alkali treatments which increased with increasing concentration at constant time. The increase in time of treatment at constant concentration had no significant effect on the moisture properties investigated.

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