International Journal of Engineering Science Invention
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org Volume 2 Issue 3 ǁ March. 2013 ǁ PP.45-49

An Investigation On Alpaca Fibre's Microstructure As A Renewable Material For Engineering Applications

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ABSTRACT: *In Recent Years, Efforts Are Being Made To Develop Renewable Sources Of Materials For Engineering And Industrial Applications As Alternatives To Petroleum Based Materials. Alpaca Fibre Is A Renewable Biobased Material That Is Mainly Produced In South And North America. In This Research Project, The Microstructure Of Alpaca Fibre Was Studied To Understand Its Structure That May Affect The Potential Use Of The Fibre As An Alternative Material For A Number Of Industrial Applications.*
Strands Of Alpaca Fibres Were Observed Under Electron Scan Microscope At Different Distance And Resolutions Both Before And After Mechanical Testing. Measurement Of The Fibre Diameters Were Also Made Along The Fibre Length And Across Fibre Samples Taken From Different Parts Of Alpaca. Significant Variations In Diameter Were Observed Along Each Fibre Length. There Were Also Variations In The Average Diameter Of Fibres According To The Part Of Alpaca From Where Samples Were Taken. These Results Were In Line With Similar Observations Of Other Natural Fibres. It Also Provided A Clue For The Mechanical Behaviour Of Alpaca Fibre And The Need For Varied Handling Of The Fibre For Specific Applications.

Keywords -*Alpaca Fibre, Bio-Based Materials, Natural Fibres, Physical Properties, Renewable Materials*

I. INTRODUCTION

The Twenty First Century Offers An Enormous Sustainability Challenges And Opportunities. This Is Consequent Upon The Increasing World Population And The Desire For Better Standard Of Living. This Desire Is Expressed In Terms Of Healthy Foods, Decent Clothing, Adequate Housing, Affordable Healthcare, And Other Necessities For Comfortable Living. Various Resources, Means And Approaches Are Being Used By Governments And Other Stakeholders At All Levels Of The Society To Achieve These Goals. However, Many Of The Resources Such As Synthetic Fibres Being Employed To Achieve These Goals Are Causing Huge Problems For The Environment. These Problems Are Evident In Environmental Pollution, Reduction In Biodiversity, And Resource Depletion Seen In Various Places All Over The World. There Is Therefore A Need To Consider And Employ Environmentally Friendly Resources And Approaches To Meet The Increasing Need Of The Populace. Natural Fibres As Renewable And Biodegradable Material Resources Are Considered As Potential Substitutes For Synthetic Fibres. The Growing Interest In The Use Of Natural Fibres Has Been Attributed To Increasing Sustainability Consciousness, Desire For Biodegradability Of Materials At Their End-Of-Life, And Increasing Stringency In Environmental Regulations In Many Parts Of The World. There Is However A Need To Evaluate The Stiffness And Strength Characteristics Of These Natural Fibres In Comparison With The Synthetic Fibres, As An Example, Fibreglass [1 - 10].

Alpaca Fibre Is A Natural Fibre Harvested From Alpaca, An Animal That Is Traditionally Raised As Fibre Producing Livestock. Alpacas Come In 22 Basic Colors, Including White, Black, Brown, Grey, Tan, And Cream. However, White Is Predominant As A Result Of Selective Breeding: The White Fibre Can Be Dyed In A Large Ranges Of Colors. There Are Two Distinct Breeds Of Alpacas: The Huacaya, Figure 1, Constitute 95 Percent Of All Alpacas While The Rarer Suri, Figure 2, Constitute The Remainder. Virtually All The Alpaca Yarn Used By Knitters Comes From The Huacaya, Whose Fibre Is Organized Into Uniform Degrees Of Waviness.

Figure 1: A Pair of Huacaya Alpacas
Source: Wikipedia [10]

Figure 2: A Pair of Suri Alpacas
Source: Wikipedia [11]

The Huacaya Have Their Fluffy Hair Sticks Straight Out From Their Bodies. Their Fibre Is Also Dense And Wooly. The Suri Have Long, Separate Locks With A High Lustre. Their Hair Hangs Down From Their Bodies In Dreadlock-Like Ringlets, Much Like The Fur Of Afghan Hounds. The Finest Part Of Alpaca Fleece Is Found On Their Back And Sides. They Are Sheared Much Like Sheep And The Fibre Is Combed, Carded, And After A Basic Cleaning Process Is Ready To Spin. Shorn Every Year, An Alpaca Will Produce A Fleece That Weighs Between Two And Four Kilogram; The Staple Length—The Length Of The Sheared Locks Without Stretching Or Disturbing The Crimp—Is Between Ten And Twenty Centimetres [11 - 14].

Alpacas Are Environmentally Friendly. They Have Padded Feet Without Hooves, Doing Little Damage To Their Terrain. They Also Digest Their Diet Of Grasses And Hay Efficiently. Their Camel Ancestry Means That They Drink Little Water. While Still Small In Numbers In United States And Canada, Alpacas Are A Growing Agricultural Business And One That Is Uncommonly Earth Friendly [11, 14]. The World Alpaca Fibre Production Is Around 5,000 Tonnes Per Year. Peru Is The Largest Producer Of Alpaca With 90% Share Of The World Market [15].

1.1 Characteristics Of Alpaca Fibre

Alpaca Fibre Is A Soft, Durable, Luxurious And Silky Natural Fibre. In Physical Structure, The Fibre Is Very Glossy And Durable. Although It Is Similar To Sheep's Wool But It Is Warmer And Not As Prickly As Sheep's Wool. The Fibre Can Be Produced As Light Weight Or Heavy Weight, Depending On How It Is Spun [11-12]. The Most Valued Attribute Of Alpaca Fibre Is Its Handle, Or How It Feels To The Touch—Creamy, Silky, Soft. While Many Factors Affect The Handle, The Diameter Of The Fibre (Fineness) Is Most Important And Is Measured In Microns (Mm). The Fibre Used To Make Most Alpaca Yarn Available To Knitters Ranges

From The Ultra-Luxurious Royal Baby, Which Is Never More Than 18 Microns, To Super-Fine, Which Averages 25.5 Microns? Alpaca Is Also Valued Because It Is Lustrous, Extremely Strong, Very Warm (Because Of The Microscopic Pockets Within The Fibres That Trap Air), Drapes Beautifully, Takes Dye

Extremely Well, And Is Not Prone To Pilling [11 - 18].Alpaca Fibre Is Valued By The Textile Industry And High Fashion Houses For Its Desirable Luxurious Softness, Warmth Without Weight, Range Of Natural Colour And Strength. Alpaca Wool Is A Renewable Biomass Resource And It Is Easily Obtainable [15].

Besides The Reported Use Of Alpaca Wool In The Textile Industry, There Is No Record Of Its Utilization For Other Industrial Applications. But It May Have Strong Potential Applications As A Renewable Biobased Industrial Material. However To Date, There Are No Reported Studies Of Its Microstructural Properties That May Warrant Its Utilization As A Material For Industrial Applications Like In Electronics, Furniture Or Automotives. The Current Upsurge In The Wave Of Studies On Natural Materials And The Growing Interest In Bio-Based Materials Necessitate A Study Of This Material To Explore Its Potential Use. In This Study, The Microstructure Of Alpaca Fibre Was Investigated To Understand Possible Impacts Of The Structure On Its Potential Use For Various Engineering Applications. Method Of Microstructure Observation Was Discussed In Section 2 While Results Of The Observations Were Discussed In Section 3. Conclusions Drawn From The Experiment And Outlook For Further Studies Were Articulated In Section 4.

II. MATERIALS AND METHOD

2.1 Material Samples

The Fibres Used In This Study Were Obtained From The Natural Fibre Centre Of Olds College School Of Innovation. They Were Sheared From Various Parts Of The Body Of Huacaya Breeds Of Alpaca. The Fibres Were Collected In Small Plastic Bags. They Were Neither Treated With Any Chemical Nor Coloured. They Were Free Of Dirt And Any Physical Impurity.

2.2. Preparation, Clamping And Testing Of Alpaca Fibre

Three Set Of Samples Were Prepared For Structural Observation Under An Electron Scanning Microscope. The First Set Of Samples Consists Of Small Mass Of Alpaca Fibres While The Second Set Of Samples Is Individual Strands Of Alpaca Wool. Two Observations Were Made Of The Second Set Of Samples. The First Observatory Study The Samples Were Made Before They Were Subjected To Stress-Strain Tests. This Same Set Of Samples Was Observed Again After Testing Their Mechanical Properties. Measurements Of Alpaca Fibre Diameter Were Taken From These Samples Along Their Lengths At Regular Distance To Observe Variation Along The Length And To Make Comparison Across Alpaca Species.

III. RESULTS AND DISCUSSION

Significant Variations Were Observed In Diameter Of Each Fibre Along Its Length. It Was Also Observed That Average Diameter Of Fibres Sheared From One Part Of Alpaca Body Vary From Those Obtained From Another Location. Before The Stress Testing, We Observed That The Alpaca Fibre Diameter Range From 13.6 To 58.8 μM, With The Average Diameter Being 28.1μM. After Stress Testing, The Diameter Was Found To Be In The Range From 13 To 37.4 μM, With 20.7μM Being The Average Diameter. In Addition, We Also Observed Bumps On The Fibres As One Could See In Fig. 1 - 3.

Figure 1 An SEM Micrograph of A Mass Of Alpaca Wool (Magnification: 1000x, Working Distance: 17.3mm)

Figure 2 An SEM Image Of One End Of An Alpaca Fibre Strand
(Magnification: 3000x, Working Distance: 10.3mm)

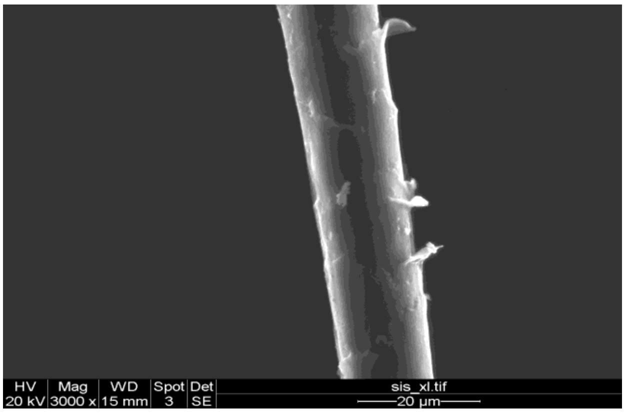

Figure 3 An SEM Image Of An Alpaca Fibre Strand After Mechanical Testing
(Magnification: 3000x, Working Distance: 15mm)

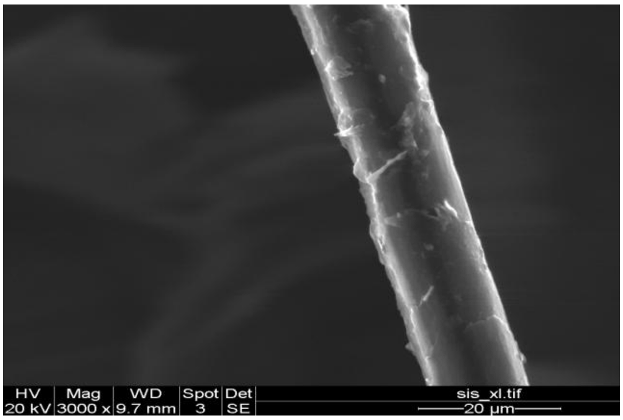

Figure 4 Another SEM Image Of An Alpaca Fibre Strand After Mechanical Testing
(Magnification: 3000x, Working Distance: 9.7mm)

There Was An Extremely Large Variation In The Observed Diameter Along The Fibers Length. Observed Large Variation In Fiber Diameter Observed In This Study Is In Congruence With Similar Study Carried Out In Argentina On Camelid's Fiber In 2006 [17]. It Appears That Such Variation Is A Normal Occurrence In Natural Fibers [5, 16]. The Observed Variation In Diameter May Likely Be Due To Differences In The Age Or Growth Of Each Fibre, The Age Of Alpaca, And/Or The Alpaca Herd Care Management. It May Also Be As A Result Of The Damage That Occurred During The Shearing Process.

IV. CONCLUSION

This Study Was Preliminary Investigation Of Microstructural Physical Properties Of Alpaca Fibre. The Knowledge Of The Physical Microstructure Is Essential To Determining The Potential Use And Handling Of The Fibre For Various Industrial Applications. Results Of The Observations On The Scanning Electron Microscopeis Helpful In Explaining The Mechanical Behavior Of The Fibreand Provided Insight Regarding

What Could Be Done In Handling The Fibre For Individual Engineering Application. Further Studies Would Beneeded In Identifying Requirements For Specific Applications. The Determination Of The Accurate Statistical Relationship And Mechanical Properties Would Also Need To Be Developed Further Over Time.

ACKNOWLEDGEMENTS

The Author Would Like To Acknowledge Various Helps Received From Dr. Shaw, Mechanical Engineering Department, University Of Calgary In The Course Of This Experimental Study, Including The Use Of The Material Lab And Scanning Electron Microscope.

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