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Extraction and characterization of marigold bast fibre

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In this study, marigold fibres have been extracted from the stem by water and chemical retting methods and their physical and morphological properties are evaluated. The longitudinal view of the fibres shows a rectangular mesh structure with grooves inside. The average crystallinity value of the fibre is estimated as 77%. The chemical composition of marigold fibre analysed by SITRA/TC/FCC methods shows that it contains around 68% cellulose. Except for the moisture regain, other physical properties do not differ significantly for thefibres extracted by both methods. The tenacity of water retted marigold fibre is 48.82 gf/tex, whereas, for chemically retted marigold fibre, it is 53.56 gf/tex. The breaking extension of fibres extracted by both these methods is around 2%. The mechanical properties, namely tensile strength, elongation, torsional and flexural rigidity, are found comparable to other bast fibres.

Keywords: Bast fibre, Biodegradable, Marigold fibre, Retting

Besides satisfying the specifications of the end product, the natural fibres play a vital role in maintaining the environmental balance. In various textile applications, the bast fibres are being used since decades in many industries, including geotextiles, insulation, and composite. These fibres are used in making temporary roads over soft land, agricultural and automotive exterior panels, acoustic and thermal insulation, furniture, recreational sports products, and marine products[1,2]. Bio-composites made from bast fibres are reliable, inexpensive, lightweight, non-toxic, and structurally sound[3]. The most important bast fibre plants include hemp, flax, kenaf, jute, and ramie. Hemp and flax are cultivated in almost all countries and harvested for both grain/seed and fibre[4].

One of the unconventional natural fibres, marigold fibre, can be extracted from the stem of the marigold plant. After harvesting the flowers, the plants are generally spread in farms for increasing the fertility of soils. Marigold plants can be grown successfully in different types of soils and climates. The germination of seeds requires temperature range 18-30°C. The planting and soil preparation of marigold plants is carried out during the summer and winter seasons. Marigold plant has 33 different species, but mostly two common species are cultivated. One of them is African marigold (*Tagetes erecta* L) and second one is French marigold (*Tagetes patula*). The African marigolds are generally tall up to 90 cm with large-sized flowers. These African marigold flowers have golden yellow, primrose, and orange colors.

The French marigold (*Tagetes patula*) is mostly dwarf, early-flowering and compact with dainty single or double blooms, borne freely and almost covering the entire plant. The color of flowers may be yellow, orange, and rusty red. The French marigold plants grow best in light soil, while the African marigold requires a rich, well-matured and moist soil.

In this study, an attempt has been made to extract fibres from the stem of African marigold plants and to investigate their characteristics.

Experimental

The African marigold stems were procured from nearby farms. Sodium hydroxide crystals were purchased from local market. The fibres were extracted from the plant by water retting and chemical retting methods.

Stagnant Water retting

Stagnant water retting method was used for the extraction of fibres from stem of marigold plant. The tied bundles of marigold stalks were immersed into stagnant water tank; the fibres were loosened and separated from the woody stalk due to progressive biological degradation. Extraction process by water retting is shown in Fig. 1.

The bundles were steeped in water ataround 40-50 cm depth. The retting process was completed in 15-20 days. Then stems were slightly brushed to remove gummy material, and to separate fibres from woody core. The fibres were then washed in clean waterand dried under sunlight.

Chemical Retting

In chemical retting, marigold stem bundles were immersed in a small bath. Chemical retting was

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Fig. 1 — Extraction process by water retting


Fig. 2 — Extraction process by chemical retting

carried out at ambient temperature (32 ± 3^0C) in a bath for 24 h, with material: liquor ratio 1:20. The concentration of sodium hydroxide was 10% w/w, with 1 g/L of water of water for 24 h. After that the stems were slightly brushed for removal of gummy material andthen thefibres were washed in clean water followed by sun drying. Extraction process by chemical retting is shown in Fig. 2

Measurement of Fibre Characteristics

The morphological structure and physical properties of marigold fibres were studied using the following methods:

Longitudinal View – The surface morphology of the marigold fibre was observed under a scanning electron microscope (JEOL JSM-6360).

Crystallinity % – X-ray diffraction measurement of marigold fibres was carried out on powder samples. The crystallinity of the powdered sample was determined by using origin 9pro software. The crystallinity was calculated by the ratio of the total area of the crystalline resolved peaks to the entire unresolved area.

Tensile Properties – The tensile properties were measured on Instron tester according to ASTM D3822 standards.

Torsional Rigidity – The torsional rigidity was measured by torsion pendulum method using the following formula:

$$\text{Torsional Rigidity } \left(\frac{\text{dyn}}{\text{cm}^2}\right) = \frac{8 \times \text{Л}^3 \times I \times L}{T^2}$$

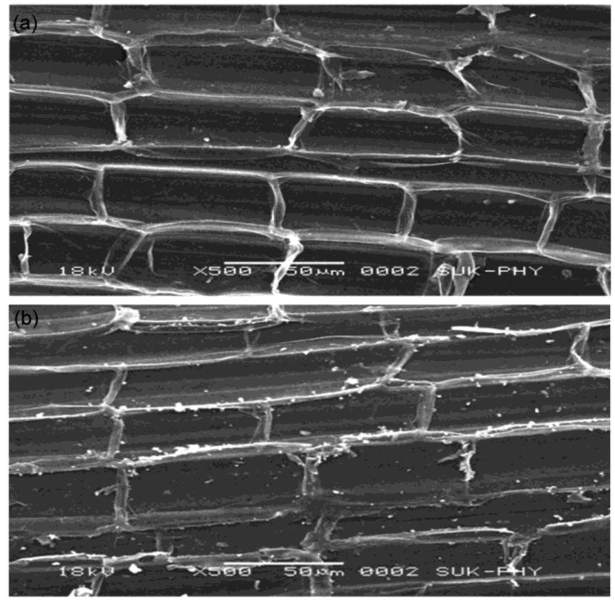

Fig. 3 — (a) Longitudinal view of water retted and (b) chemical retted fibre

where *I* is the moment of inertia of bar about the fibre; *L*, the length of specimen; and *T*, the period of oscillation.

Flexural Rigidity – The flexural rigidity was measured by ring loop method using the following formula:

$$\text{Flexural Rigidity } \left(\frac{\text{Mn}}{\text{mm}^2}\right) = 0.0047 \times W \times (2 \times \text{Л} \times r)^2 \times \frac{\cos\theta}{\tan\theta}$$

where *w* is the weight of rider in mg; *r*, the radius of rod in mm; $\theta = \frac{493d}{2\pi r}$; and *d*, the deflection of lower end of loop.

Moisture Regain (%) – The moisture regain was measured according to ASTM D2495-07 standards.

Results and Discussion

The characteristics of marigold fibresare measured for both water retting and chemical retting methods.

Morphological Properties

The longitudinal view of water retted marigold fibre taken on scanning electron microscope shows the rectangular mesh structure with grooves inside the mesh [Fig. 3 (a)].

The longitudinal view of chemically retted fibre shows surface texture similar to the water retted fibre with considerable damage, due to the action of NaOH [Fig. 3 (b)].

The crystallinity of fibre measured by diffraction curve for water and chemical retted fibre is found 76.11% and 78.20%, respectively (Fig. 4). It shows

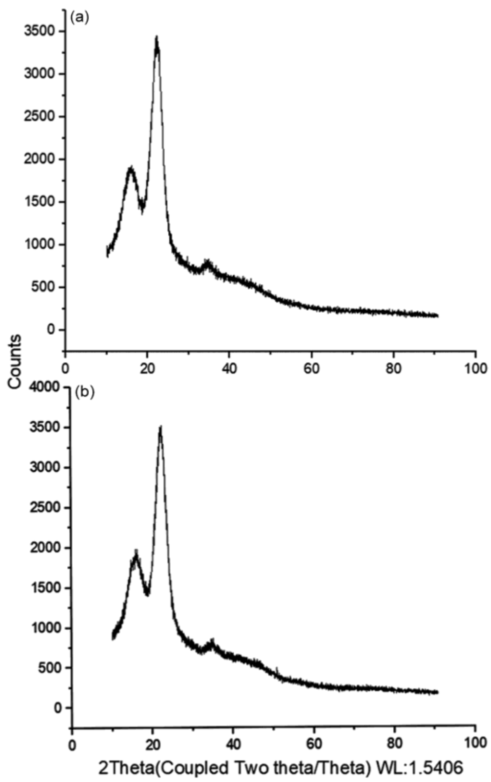

Fig. 4 — Crystallinity (%) of (a) water retted and (b) chemical retted fibres

that there is no significant effect of the retting method on the crystallinity of fibres, since crystallinity is an inherent property of fibres.

The chemical composition of marigold fibres, measured by SITRA/TC/FCC methods, is:

- Cellulose (Method: SITRA/TC/FCC/01): 68.7 %
- Lignin(Method: SITRA/TC/FCC/02): 10.2 %
- Wax (Method: SITRA/TC/GT/09): 0.18 %
- Ash (on dry basis) (Method: IS 199): 0.88 %
- Pectin: 5.3 %
- Hemi-cellulose: 14.74 %

Physical Properties

Tenacity of water retted marigold fibreisfound to be 48.82 gf/tex, whereas for chemically retted marigold fibre, it is 53.56 gf/tex. Marigold fibre shows comparatively higher tenacity values than jute fibre (30-50 gf/tex)[1]. The percentage breaking extension of water retted fibre is 2.02 and chemically retted fibre is 2.28. There is no significant difference in tenacity and breaking extension between water retted and chemically retted fibre.

The torsional rigidity of water retted marigold fibre is 99.99 dyn/cm^2, and that of chemically retted marigold fibre is 82.29 dyn/cm^2. The chemically retted marigold fibre depicts comparatively lower resistance to twisting, which may be due to the removal of more amount of lignin in water retted fibre. The twisting mainly occurs between the cellulosic molecules, while chemically retted fibreslead to the twisting of whole structure, which may require less twisting force. However, statisticallythere is no significant difference between water and chemical retted fibres.

The flexural rigidity of water retted marigold fibre is 0.786 mN/mm^2, whereas chemically retted marigold fibre shows rigidity value 1.034 mN/mm^2, which shows that there is no significant difference in flexural rigidity between water retted and chemically retted fibres. In water retted fibres, due to the removal of more amount of lignin, the fibre becomes more flexible in comparison tochemical retted fibre. Hence, the flexural rigidity is higher for chemical retted fibre.

The water retted marigold fibre shows significantly higher regain in comparison with chemical retted fibre. In chemical retted marigold fibre, the lignin content is higher, which may absorb less amount of moisture. Hence, the chemically retted marigold fibre depicts significantly lower moisture regain.

The longitudinal view of water retted and chemical retted marigold fibre shows rectangular mesh structure with grooves inside the mesh. The estimated average crystallinity value of marigold is around 77%. The strength of marigold fibre is around 50 g/tex. Torsional rigidity and flexural rigidityvalues for both water and chemical retted fibres are not significantly different. The moisture regain of water retted fibre is significantly higher than that of chemically retted fibre.The chemical composition and properties of marigold fibreare found closer to jute fibre. The marigold fibre may find applications in various technical fields, such as composites, medical textiles or apparels after blending with other textile fibres.

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