PREPARATION OF RADIATION GRAFTED CELLULOSE BASED BIODEGRADABLE SUPER ABSORBENT POLYMER (SAP) FOR THE APPLICATIONS OF AGRICULTURE

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INTRODUCTION

Grafting can be defined as a polymer modification where a different monomer is attached to an existing polymer through a covalent attachment irreversibly. Grafting is a free radical process, which can be initiated chemically, photo-chemically or by using ionizing radiation. Ionizing radiation is used for radiation grafting. It has several advantages over conventional grafting methods Such as that it can be done at room temperature, high efficiency, high purity, being environmental friendly, simple, accurate, easy to control and a clean process (Yatender et al., 2014).

Ionizing radiation is a type of radiation composed of particles/photons that individually carry enough kinetic energy to liberate an electron from an atom or a molecule with which it interacts, e.g. gamma radiation, X-rays, beta and alpha particles or machine accelerated particles. Ionization radiation sources are of two types, one is radioactive sources which emit radiation due to their nuclear instability e.g. alpha, beta, gamma radiations and the other, machine generated radiation e.g. electron beam, cyclotrons. Gamma rays are more popular in the world. It initiates radiation grafting polymerization process. Radiation grafting is a promising technology having several potential applications. It can be performed using three common methods; i) Grafting by simultaneous or mutual irradiation (polymer backbone and monomer are simultaneously irradiated using electron beam or gamma rays under vacuum or an inert gas environment) ii) Grafting initiated by pre-irradiation in vacuum or inert atmosphere and iii) Grafting initiated by per oxidation (pre-irradiation in air) (Yatender et al., 2014).

Different countries practiced to develop radiation grafted material for industrial application and environment preservation such as radiation grafted materials for water purification, fuel cell membrane, energy storage in battery cells and Super Absorbent Polymers (SAP) for agricultural application using these three grafting techniques. This paper discusses development of radiation grafted SAP for agricultural application.

Super Absorbent Polymers (SAPs) are highly swollen, hydrophilic polymer networks capable of absorbing large amounts of water or saline solution (Lu et al., 2003). These substances can hold 100-1000g of water per dry gram of SAP (Ramazani-Harandi *et al*., 2006). SAP is having the possibility of being applied in a wide range of industries such as agricultural, medicinal, environmental, horticultural etc. Cellulose based biomaterials could be used as raw materials for developing SAP with high biodegradability, having high strength after absorbing water, having less water soluble components, strong water retaining ability and mould proofing ability (Czaja et al., 2007). Most agricultural residues such as corn stove, wheat straw, rice straw and bagasse which are referred to as lignocellulosic materials are rich in cellulose fibers.

The present study is focused on synthesizing Sri Lankan SAP from bagasse cellulose. Additionally acrylic Acid (AA) and cellulose grafting by mutual gaffing using N,N-MethyleneBisAcrylamide (MBA) as a cross linker. This SAP is employed for the application

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in the agricultural field to overcome problems of water scarcity in dry zone and difficulty of continuous watering in urban areas.

OBJECTIVES

General objective is,
To develop biodegradable cellulose based "Sri Lankan SAP" by gamma irradiation process.
Specific objectives are,

To evaluate the amount of cellulose available in bagasse
To develop and characterize the Sri Lankan SAP

METHODOLOGY

Cellulose was prepared by using alkaline pretreatment method as described by Feng et al., (2010) and its percentage determined using chlorinated method as described in Google book, (2004). SAP was prepared using a setup as shown in figure 1. A Certain amount of the cross-linker N'N- MethyleneBisAcrymide (MBA), Acrylic acid and 5 mol/L NaOH solution were mixed and kept in an ice bath for neutralization prior to use. 1.0 g of bagasse cellulose and 50 ml of de- ionized water were added to the vacuum flask and stirred for 15 minutes at 60^0C. Blend in the ice bath was added to the media and continuously stirred for 5 minute at the same condition. Media was quickly transferred to a glass container and nitrogen gas was bubbled for a few minutes and quickly sealed. Sealed product was placed in the gamma cell and irradiated under a dose of 20 kGy. The final product was cut in to small pieces and dried at 105 ^{o}C until a constant weight was observed. Un-grafted cellulose samples as well as grafted SAP were Fourier Transform Infra-Red (FT-IR) spectroscopy analyzed and grafted SAP was subjected to analysis in a Scanning Electronic Microscope (SEM) for morphological characteristics. Swelling ratio was determined by immersing 1 g of SAP in a 200 - mesh sieve pouch in 250 ml of Tap water kept overnight. The swelling ratio (Q) was calculated using the formula, $Q\ (g/g) = (m_1-m_0)/m_0$ (Where m_0 and $m_1$are the weights of the dry and swollen SAP respectively). Biodegradability was measured by embedding nylon cloth wrapped around 100 g of water absorbed SAP to a depth of 10 cm in pots filled with sandy loam soil. This was repeated three times and each sample was weighed at 14 days intervals until total degradation was attained. The percentage of biodegradability was calculated using the formula; $(m_s-m_d)/m_s \times 100\%$ (Where m_s the weight of the un-degraded SAP and m_d is the weight of the biodegraded SAP).

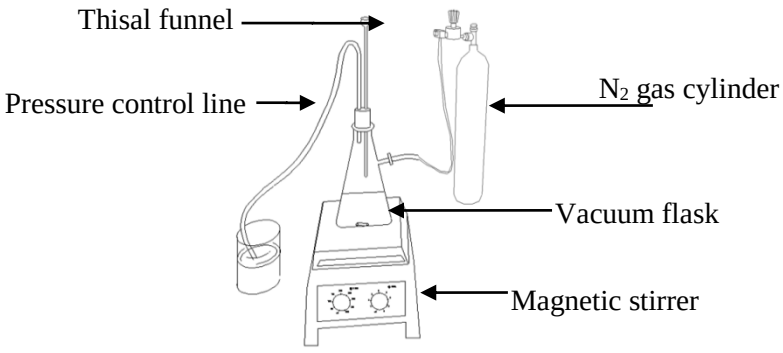

Figure 1. Setup of instrument for mixing chemicals

RESULTS AND DISCUSSION

According to the result of cellulose determination, 83% cellulose was in the bagasse after alkaline pretreatment. Swelling ratio was 1:310 in tap water. According to FTIR results un-grafted cellulose (Figure 2) shows that the main characteristic peaks of cellulose are at 1162.1 cm^{-1}, 1070.7 cm^{-1}(pyran structure) 3483.2 cm^{-1} and 3427.1 cm^{-1} (O-H Structure) and 2927 cm^{-1}(C-H stretch). The small peaks at 1637.6 cm^{-1} 1458.4 cm^{-1} result from –C=0 stretching and amorphous cellulose, respectively. The absorption band at 1378.7 cm^{-1} and 897.8 cm^{-1} are

described to C-H bending vibration. Grafted SAP (Figure 3), the peak at 1716.9 cm^{-1} corresponded to the carboxyl absorption from grafted Poly Acrylic Acid (PAA) and the peak at 807 cm^{-1} is also characteristic the PAA. Furthermore, the bands at 1569.6 cm^{-1} and 1398.2 cm^{-1} were corresponded to the sodium carboxyl group. These indicate that the PAA (Na) was grafting to cellulose. SEM indicates clear inter connected porous surface in SAP (Figure 4). This surface morphology may accelerate the penetration of water into the polymer network. The SAP was degraded successfully at incorporated sandy loam soil in 70 days at 29^0C soil and 32^0C atmospheric temperatures (Figure 5). According to results of our study, swelling ratio was 310 times its own dry weight after 24h. According to the definitions for the Super Absorbent polymer, it must need to have 100-1000g of swelling of its own dry weight. Swelling ratio of our product was in super absorbent range. The mutual radiation grafting depends on the experimental parameters such as nature of substrate, type and concentration of monomers, absorbed dose, and condition of atmosphere. In our experiment, maximum dose from gamma cell (20kGy) and nitrogen atmosphere (to reduce oxidation) was used. However a concentration of acrylic acid was limited to 20% as it was more economical. Further research is being considered to improve swelling ratio of super Absorbent Polymer developed so far by decreasing size of cellulose particles and method applied to reduce homo polymerization.

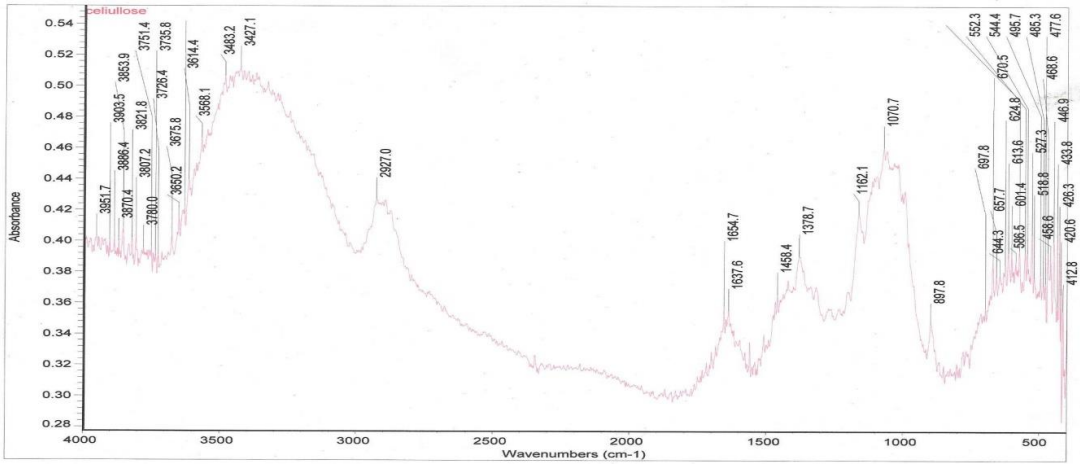

Figure 2. FT-IR result of UN graft cellulose

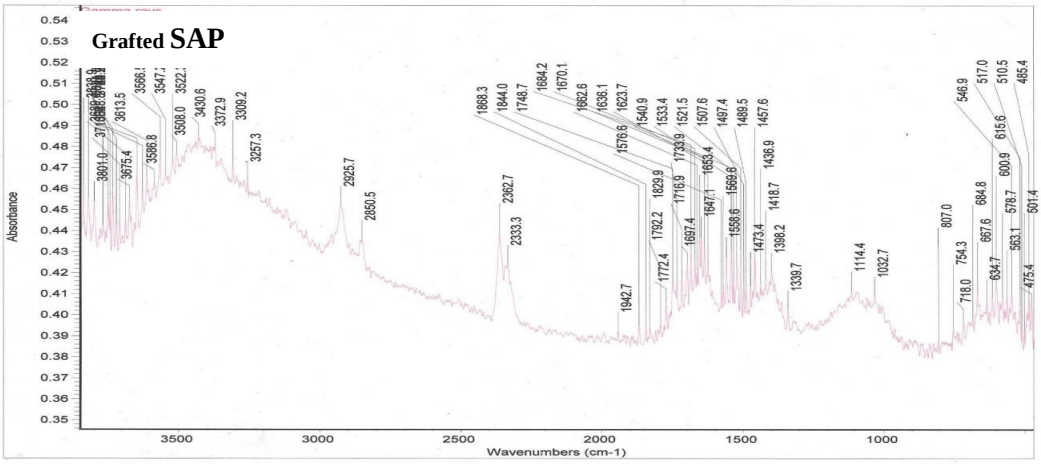

Figure 3. FT-IR result of grafted SAP

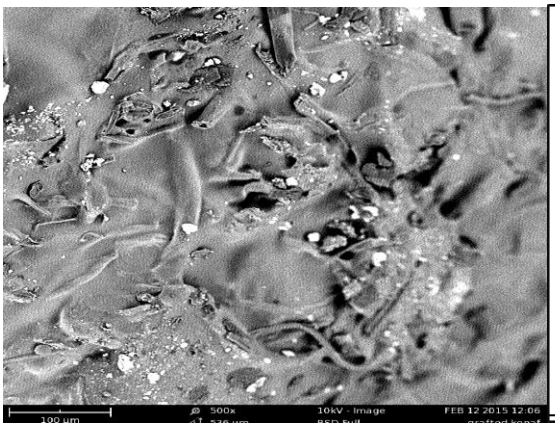

Figure 4. SEM diagram

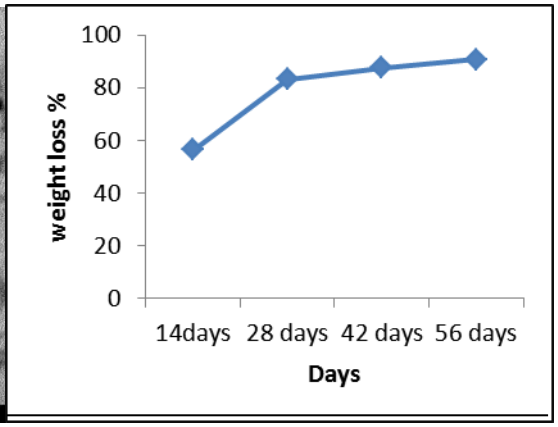

Figure 5. Variation of biodegradbility

CONCLUSIONS

Superabsorbent polymer was prepared by graft polymerization of acrylic acid onto the chain of cellulose from mutual grafting. The grafted product had a porous structure and swelled 310 times on its own dry weight with tap water. It degraded successfully after 70 days at 29^0C soil and 32^0C atmospheric temperatures in sandy loam soil.

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