DEVELOPMENT OF RADIATION GRAFTED SUPER WATER ABSORBENT POLYMER MATERIAL FOR ARID AREA AGRICULTURE IN SANDY SOIL

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INTRODUCTION

Radiation grafted super water absorbent polymers (SWAPs) can absorb and retain large amounts of water relative to their own mass and has slow water releasing capability. These materials have excellent hydrophilic properties, high swelling capacity and high swelling rate. SWAPs can be effectively used in agricultural applications owning the aforementioned properties [1, 2]. Gamma radiation- induced grafting technique is used to develop SWAPs since it offers a number of advantages such as ease of processing at room temperature, low energy consumption and no need of initiators [3]. Use of this technique provide both grafting and crosslinking during the irradiation where grafting form support for the degradation enhancement and the crosslinking from support to hold the 3-D structure of the product. This crosslinking network is essential for the water retaining capacity of the product. In this research, a SWAP material was developed by radiation-induced grafting of acrylic acid (AAc) monomer onto cassava starch (SL-SWA-T-3). Cassava starch is a natural commonly available biodegradable material found in many areas of the country. The maximum absorption of the developed product and the commercially available products show almost same values in between 20,000-25,000%. However, some of the agricultural areas in Sri Lanka like Kalpitiya need high absorption rate rather than maximum absorption due to its sandy soil condition. It is one of the areas in Sri Lanka that cultivates vegetables for the local market. SWAP is the most suitable option for this type of area and higher absorption speed within first 10 minutes is the most important feature and key factor. Therefore, our study is especially focused on improving the absorption speed of the developed SWAP along with the optimization of the other properties such as the maximum water absorption percentage and the time required to release 50% of the absorbed water with compared to the commercial product in order to provide a proper solution to address the above mentioned issues in the country.

METHODOLOGY

Materials

Cassava starch, Acrylic acid (AAc), potassium hydroxide (KOH), polysorbate 20 (Tween 20) and glycerol. All chemicals were of commercial grade. Distilled water was used in all the experiments.

Method

135.9 g of Cassava starch was added to 469.3 g of water and stirred using a mechanical stirrer until homogeneous dispersion of starch. Then 5.0 g of glycerol dissolved in 50 ml water was added and stirred for 10 min. A solution of 48.9 g of KOH in 100 g of water was added slowly to the mixture with stirring for 45 min. Then 135.9 g of AAc mixed with 5 g of Tween 20 dissolved in 50 ml of water was quickly added to the mixture and stirred for another 1 hr. This mixture was packed in polythene bags and irradiated at 4 kGy dose via a Co-60 gamma-irradiator at a 0.33 kGy/h dose rate. The irradiated samples were dried in the oven and extruded into small parts using an extruder machine. About 5 g of this sample was dipped in

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1000 ml of water and the corresponding mass values at different time intervals were measured. All the experiments were done for 3 replicates. The water absorption and releasing percentages were estimated by the percentage increase and decrease of weights respectively according to Eq.1 and Eq.2.

$$Water\ absorption\ \% = \frac{(W_t - W_i)}{W_i} \times 100 \quad (1)$$

Where W_i and W_t indicate the initial dry weight and weight after absorbing water at time t.

$$Water\ releasing\ \% = \frac{(W_i - W_t)}{W_i} \times 100 \quad (2)$$

Where W_i and W_t indicate the initial saturated weight after 10 days and weight after releasing of water at time t.

RESULTS AND DISCUSSION

The water absorption capability was studied to characterize the developed SWAP in terms of its water absorption capacities. Figure 1 shows variation of the water absorption capacity with time. To assess the water absorption capacity of newly developed SWA, the water absorption capacity of developed SWAP is compared with commercially available SWA (Figure 1). The maximum absorption capacity of developed SWAP reached the range of 22,000-25,000% in ten days. The commercially available SWAP also shows similar behavior. This implies that both the developed and commercial SWAPs show similar water absorption performance pattern with higher absorption percentages.

The water releasing performances of developed SWAP was also evaluated. The slow releasing ability of water from the SWAP is a major requirement for the possible application of the SWAP in dry zone agriculture. The slow releasing of water maintains required soil moisture level for agricultural activities in dry region. The water releasing behavior of both developed and commercial SWAP was studies up to ten days (Figure 2). The trend of water releasing is favorably slow for both developed and commercial SWAP and both show similar nearly linear behavior during the period of time under investigation. This suggests that the developed SWAP can be used as water releasing agent for longer period of time for arid area agriculture.

The quick absorption of water and retention for longer period of time are important factors for the feasible use of SWAP in arid area agriculture. The quick absorption of water by SWAP is extremely important for the use of SWAP in arid environment. This property allows the applied water to be rapidly absorbed and retained specially in sandy arid soil. If not retained, the applied water is rapidly drained through large capillary spaces in sandy dry soil. The early water absorption behavior of developed SWAP was studied. It showed that the developed SWAP reached the absorption percentage of 4500 within two minutes and reached about 6000 at 10 minute whereas this capacity for commercial SWAP is around 1000 at two minute time and 2700 at ten minute time respectively (Figure 3). This indicates that the developed SWAP shows faster water absorption behavior than the commercially available SWAP. In this respect the developed SWA shows superior water absorption properties compared to commercial SWAP.

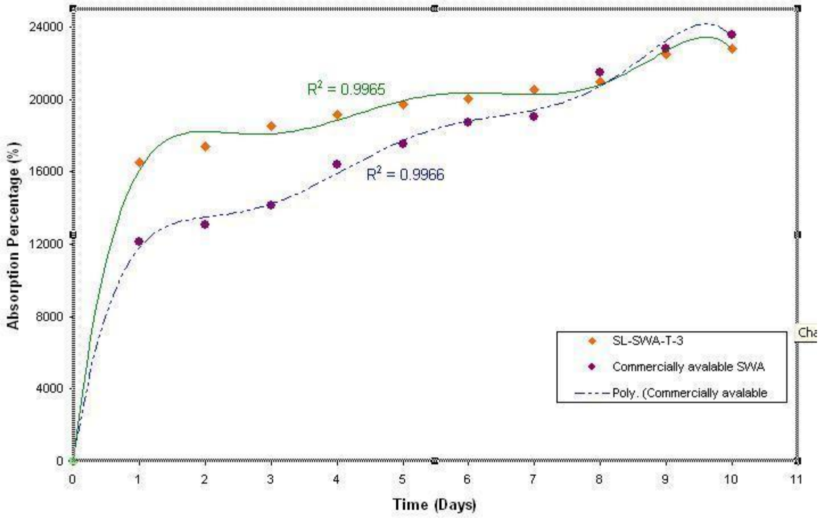

Figure 1. Variation of water absorption percentage within first 10 days

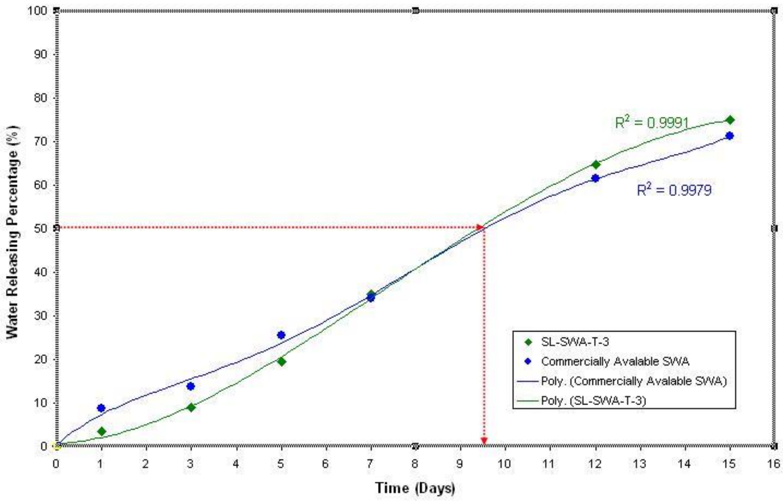

Figure 2. Variation of percentage of water released with time for developed and commercial SWAPs

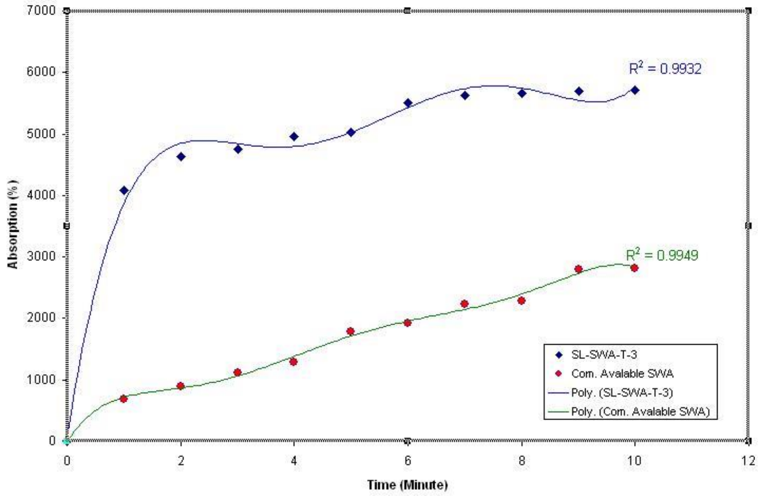

Figure 3. Variation of water absorption percentages during first ten minutes

CONCLUSIONS

In this study radiation grafted and cross linked SWAP is successfully developed and characterized in terms of its application in water absorption, retention and slow release. Both the developed and commercial SWAPs show similar water absorption and releasing properties. However, the water absorption rate during the first 10 minutes of the developed SWAP was two times higher than the commercial SWAP. This indicates that the developed SWAP can be successfully used in arid area agriculture in Sri Lanka especially in dry sandy soil in which the water retention is very poor. Further, the developed SWAP could be a potential water retaining agent that can contribute to expansion of agricultural practices to the area currently not feasible due to the low rainfall and lack of irrigation.

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ACKNOWLEDGMENTS

The authors are thankful to Sri Lanka Atomic Energy Board for financial support and International Atomic Energy Agency for the contribution under the RCA Project RAS1014/9003/1.