Annex 6-1

Summary of Country Reports on Super Water Absorbent (SWA)

Current Status and Cost Effectiveness toward Commercialization

1) Bangladesh (Dr Salma Sultana, Bangladesh Atomic Energy Commission (BAEC))

Indiscriminately use of chemical fertilizers is one of the main factors that limit the production of agricultural products. To get maximized and environment friendly agricultural products, it is very important to improve the utilization of water resources and fertilizer nutrients. Incorporating fertilizers into a superabsorbent polymeric network is an effective method for enhancing the utilization efficiency of water and fertilizer. In this study, a Super Absorbent Polymer was prepared from CMC and Acrylamide by using gamma radiation. Methylene blue dye was used as a model for fertilizer adsorption study. The adsorption data were then fitted in Freundlich Adsorption isotherm and from that the adsorption was found to be feasible with the n value greater than 1. Besides, we studied water adsorption in presence of urea fertilizer solutions of various concentrations. In presence of urea water absorption increased drastically to around 31840 % from 24579 % in distilled water. This happens due to the interaction of urea with the hydrogel. These adsorption studies reveal that our prepared hydrogel can potentially be used for slow release of fertilizer as well as super water absorbent.

2) China (Prof Dr Li Jingye, Shanghai Institute of Applied Physics, Chinese Academy of Sciences)

Laundering durable cotton fabrics functionalized with, such as superhydrophobic, self-cleaning, anti-bacterial properties, can be obtained by means of radiation-induced graft polymerization methods. It could be achieved via the graft polymerization of functional monomers or co-graft polymerization of the monomers and certain nanoparticles[1-5]. The laundering durability lies in the formation of the covalent bonds between the cellulous macromolecules and the graft chains or together with the nanoparticles, which is the most advantage of the radiation methods in fabric modification.

Also in the lab-scale experimental study we conduct the graft polymerization under the irradiation of γ-ray, the electron-beam accelerator will be more suitable for the industrial-scale production. In recent years, we conducted the roll-to-roll graft polymerization of the functional monomers onto cotton fabrics under the self-shielding electron-beam accelerator. The procedure went quite smoothly with acceptable treating speed and degree of grafting of the resulted functional cotton fabrics.

Our results reveal that the electron-beam accelerator would be a powerful facility for the production of the functional fabrics, including cotton fabrics.

3) Indonesia (Dr Darmawan Darwis, National Nuclear Energy Agency of Indonesia (BATAN))

Super water absorbent hydrogel (SWA) was prepared by radiation graft copolymer of cassava starch-polyacrylic acid. The SWA has the ability to absorb water up to 300 times of its dry weight. The SWA can be used to maintain the humidity of soil by releasing water from its structure to surrounding environment. Three different concentrations of SWA (0.1 gram/kg soil, 0.2 gram/kg soil, and control) were tested to the Caisim (Brassica juncea L) plant in pot system to evaluate the soil water content, the total microbes in soil, soil microbe activity, plant growth and fresh biomass. The SWA was placed 10 cm inside the soil. The plant was irrigated everday, every 2 days, and every 4 days, respectively. The results show that SWA 0.1 g/kg soil give the highest water content among the SWA concentration used. Total microbes in soil increase with increasing of SWA concentration and it is influenced by watering interval time. For example, total microbes (CFU/g of soil) in soil for SWA with a concentration of 0.1 gram/kg soil, 0.2 gram/kg soil, and control with watering interval every day were 12.42 X 108, 14.89X 108, and 5.951 X 108, respectively. The presence of SWA in soil improves soil respiration indicating that number of microbes in soil increase. In addition, application of SWA with a concentration of 0,1g/kg of soil increases the fresh biomass of Caisim about 3 percent even though the increase was not significant statistically.

4) Malaysia (Dr Marina Binti Talib, Malaysian Nuclear Agency)

Sago waste has been successfully modified through radiation technique to produce superadsorbent. The fibre from sago waste was mixed with monomer, water soluble polymer and alkaline solution prior to radiation process. Graft polymerization and crosslinking using radiation processing technology are the attractive techniques for modification of chemical and physical properties of polymers. Infrared spectroscopy (FTIR) and scanning electron microscopy (SEM) were carried out to confirm the chemical structure and morphology of the superadsorbent. FTIR confirms the acrylic acid has been grafted to sago waste. The open and bigger average pore size of superadsorbent sago waste as compared to origin sago waste resulted in a decrease in degree of swelling. The use of modified sago waste as adsorbent was successfully performed. It can be observed from the results obtained from the treatment of POME for removal of suspended solid, colour and oil and grease.

5) Mongolia (Mr Sukh Odkhuu, National University of Mongolia)

The super water absorbent (SWA) material was produced using carboxymethyl cellulose (CMC) by gamma irradiation. We did few experiment on SWA for study on properties.

1. Swelling speed of the products: The first hour SWA product swells up to 150 times of its mass and saturates after 6 hours of immersing SWA product in water.

2. Ability of holding water: The SWA tested in sandy soil for its moisture effect. As a result, pure sand was hold its moisture for a week, whereas sand with SWA was ~5% moisture after 15 days and dried-up completely after 20 days .

We conducted pot experiment on tomato seeds with different mixtures of SWA. Tested three different mixtures of SWA such as a CMC, CMC straw mixture and CMC husk mixture. Those were all irradiated 10kGy dose by gamma.

The first germination was CMC, CMC straw and CMC husk on the 7th day after seed, control was on the 9th day after seed. After 25 days, measured height and counted leaves of tomato trees. The average height of tomato trees with SWA were 12%-70% higher than control and average number of leaves 108%-228% higher than control.

6) Philippines (Dr Lucille V. Abad, Philippine Nuclear Research Institute (PNRI))

Super water absorbents (SWA) based from cassava starch/acrylic acid (AAc) were prepared by gamma irradiation for use as soil water retainers. Parameters such as degree of neutralization (DN), concentration and ratio of cassava starch to acrylic acid and irradiation dose were optimized. Gel fraction of the different SWAs ranged from 40-90% and degree of swelling reached up to about 6-400 g water /g dry SWA. The SWA gave a mechanical strength up to 1000 kPa. The developed SWAs can retain water up to 20 days in soil in pot experiment. Physico-mechanical characterization showed that 30% acrylic acid concentration, 30% and 60% degree of neutralization, and irradiation dose of 10-20 kGy are suitable parameters for the synthesis of cassava starch/AAc SWA. Initial result on the soil water retention experiment, maintained for 3 months with a two-week rehydration cycle, the most efficient SWA is formulated at 30% AAc and 60% DN and 10 kGy. Additional features of developed SWA involve its ability to adsorb heavy metals, such as nickel and copper, which can be used to remediate contaminated sites (e.g. near mining areas and dump sites) and convert them into agricultural lands.

New Research and Obstacles after Commercialization of SWA

1) Kazakhstan (Mr Alexandr Borissenko, JSC " The Park of Nuclear Technologies")

SWA application in agriculture of Kazakhstan is determined by a considerable amount of crop areas and significant droughts in many regions.

Since 2013 there are research works to adopt radiation processing technology for cross-linking of polymer compound containing acrylic acid, carboxymethyl cellulose and potassium hydroxide on ILU-10 electron accelerator. Consequently a stuff with water saturation factor over 300 gram of water per 1 gram of dry SWA has been received.

In 2014 the Nuclear Technology Park JSC has received patent for an invention "Method for the Production of Water-absorbing Polymer" No.32080 dated 30.09.2013.

In the following years there were research works aimed at selecting optimum stuff composition, adjusting of accelerator operating conditions and transferring from research to limited production.

Major efforts have been done, resulting to laboratory research on synthesis of SWA based on polyacrylic acid with the available blend compositions and with the reduced content of acrylates. A safe and cost-effective method for SWA production has been defined and appropriate machines have been chosen – tablet press and packaging machine. Drying process has been excluded in view of its energy-consuming. The suppliers of imported potassium polyacrylate have been selected. As for the suppliers of the second component - carboxymethyl cellulose there is a domestic producer PromCellulosa LLP (Shymkent).

The main work to test proof samples is being conducted in a growing-room of the Nuclear Technology Park JSC. The project team has offered the method for the production of SWA made of potassium polyacrylate that allows excluding aggressive acrylic acid and potassium hydroxide in the production process. That decision allows considerably increasing operations safety and reducing environmental risks.

2) Japan (Dr Mitsumasa Taguchi, National Institutes for Quantum and Radiological Science and Technology)

Gel indicator/dosimeter was produced by the radiation cross-linking technique for an evaluation of radiation dose under the cancer treatment. Gel indicator/dosimeter has been developed for commercialization by the regional consortium of QST, public institutions and private company. Dose on the gel indicator/dosimeter is quantitatively read out by a flatbed scanner with special software, and two- and three-dimensional dose distributions are to be obtained. Numerical data of the dose distribution is adapted to DICOM format, which is used for other medical devices such as X-ray CT and MRI.

3) Thailand (Dr Phiriyatorn Suwanmala, Thailand Institute of Nuclear Technology (TINT))

The Thailand Institute of Nuclear Technology (TINT) cooperates with the Office of the Rubber Replanting Aid Fund (ORRAF) under a project called "Bioplastic Root trainer and Super water absorbent (SWA) for Increasing Survival of Rubber Implantation". The project was funded by Bureau of the Budget under Ministry of Finance with a budget of US$15,000 per year for three years. TINT will supply bio-degradable root trainer for the young rubber plants and will also supply SWA during implantation. ORRAF will be responsible for the rest of the project, from locating the suitable field to data collection. The experiment was carried out with randomized complete block design (RCBD) with five replications for six treatments. The SWA with the amount of 0, 10, 20, 30, 40 and 50 gm was applied. The percentage of survival of rubber trees was compared with that of untreated rubber trees. In addition, the effects of SWA on the survival of rubber trees was investigated in terms of wither, wilting and budding. Results from data collected show that application of SWA 30 gm per one rubber tree can increase the percentage of the survival of rubber tree to 77%. Moreover, SWA helps the growth of rubber tree by increasing budding and reducing wither as well as wilting.

Tint received US$150,000 from the Thailand Research Fund (TRF) and Mitr Phol Sugarcane Research Center Co. Ltd. to research on the preparation of super water absorbent cellulose from sugarcane bagasse using gamma radiation and electron beam for agricultural application. The research will commence during the first quarter of 2018.

4) Vietnam (Dr Nguyen Ngoc Duy, Vietnam Atomic Energy Institute (VINATOM))

Recent years, we have attempted to improve the SWA characteristics, formulations and methods aiming at making its price decreasing strongly and persuading the end-users to apply this product in places where it rains too little or the drought may happen. The first SWA was made from cassava starch radiation-grafted with acrylic acid as resulted in high selling price. The starch-based SWA has been delivered to a domestic market with an averaged quantity of some tones a year. The market need for consuming this product still exists without an increase year by year. The main reason for this obstacle is a high selling cost. So we are studying to develop the next generation SWA with a lower cost. Instead of using starch as a substrate and high content acrylic acid monomer by a radiation graft process, we have applied the radiation polymerized process on either bentonite or coir dust added together with lower-content acrylic acid. We have determined their water absorption and de-absorption properties. It is concluded that these properties of materials are equivalent to that of the starch-based SWA. We have tested on bench scale for good effectiveness of soil humidity condition of two types of these products. And then another disadvantage is hard to overcome. That is how to persuade farmers, who learn and follow our advice on the new cultivation with SWA combined usage for saving water. At present, we have been concentrating on mixing SWA and useful bacterium-cultivated manure to improve the impoverished soil, to grow nitrogen-fixed bateria stronger and to enhance the soil stability as well.