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NaPSS-exposed different amounts of gamma radiation doses: An evaluation in sight of dosimetric aspects

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Abstract
The field experiment was conducted to evaluate the "Effect of soil and foliar supplementation of nitrogen, boron and salicylic acid on growth and yield of cucumber (*Cucumis sativus* L.) in alfisols of Konkan (M.S.)" at Research and Education Farm, Department of Agricultural Botany, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (M.S.) during the Summer season of 2018. The experiment was laid out in Randomized Block Design (RBD) comprising ten treatment combinations replicated thrice, where the effect of soil and foliar supplementation of nitrogen, boron and salicylic acid either alone or in combinations applied along with the recommended dose of fertilizers (135:60:30 NPK kg ha^{-1}) and an absolute control (to judge the fate of native nutrients) were studied. The study further revealed that the treatment receiving the application of recommended dose of fertilizer (135:60:30 kg ha^{-1}) + Foliar spray of nitrogen through urea (1%) + Soil application of boron through borax @ 2 kg ha^{-1}+ Foliar spray of salicylic acid (0.2%) was recorded the highest fruit yield (231.22 q ha^{-1}) and yield attributing characters like number of fruits per vine (7.00) and weight of fruit i.e., 1.98 kg per vine as well as growth parameters *viz.* vine length (407.00 cm) and number of branches per vine (14.22) of Cucumber in alfisols of Konkan (M.S.).

Keywords: Thermally stimulated luminescence (TSL), electron spin resonance (ESR), Fourier transform infrared (FTIR), gamma irradiation, polymer dosimeter

Introduction
Sodium polystyrene sulfonate (NaPSS) is a medication that is commonly used to treat high levels of potassium in the blood, a condition known as hyperkalemia. As with any medication, there are dosimetric aspects to consider when using NaPSS. The dosimetric aspects of NaPSS primarily revolve around the dose of the medication that is administered. The dose of NaPSS can vary depending on the severity of the hyperkalemia, the patient's age and weight, and other factors. One of the key considerations with NaPSS is its potential to cause gastrointestinal (GI) damage. This can occur if the medication is not properly prepared or administered. To minimize this risk, it is important to follow the manufacturer's instructions carefully and to use caution when administering SPS to patients with a history of GI disorders.

Another important dosimetric aspect of NaPSS is its potential to interact with other medications. NaPSS can bind to other drugs and interfere with their absorption and effectiveness. Therefore, it is important to monitor patients carefully when administering NaPSS in conjunction with other medications. Finally, it is important to consider the potential for NaPSS to cause electrolyte imbalances. NaPSS works by exchanging sodium ions for potassium ions in the GI tract, which can result in changes in the patient's electrolyte levels. Careful monitoring of electrolyte levels is therefore necessary when using NaPSS.

Polymer dosimeters compete with other types of conventional radiation dosimeters due to their ease of use and range of radiation-dose measurement [1, 2]. Further, they are available at a low cost and are easily made into very thin forms. As such, various types of polymers are used for dosimetric applications. Regarding the experimental techniques, the thermally stimulated luminescence (TSL) [3], electron spin resonance (ESR) [4] and spectrophotometric techniques [5] are very popular. Recently, Rajendra Prasad *et al.* [6] have explored the possibilities of AA AMPS copolymer for dosimetric applications.

TSL dosimetry is based on the principle that the TSL intensity is proportional to the radiation dose; the sample can be used for dosimetric applications. Same principle holds good for ESR and FTIR technique also.

Based on the principle, Janson [7] has reported on luminescence dating and environmental dosimetry. Bas [8] has reported on TSL dosimetry based on inorganic compounds like lithium fluoride (LiF). Alexander and Charlesby [9] have exposed solutions of polyvinyl alcohol (PVAL) to different radiation doses. Based on the amount of gases evolved on exposure to gamma irradiation, these authors investigated dosimetric aspects of PVAL. Abou El Kheir *et al.* have [5] reported α-particle polymer detectors, with lexan plastic as material. These authors have observed excellent linearity of FTIR absorption band intensity against radiation dose. Therefore, lexan can be used for α-particle detection purpose. Sodium salt of polystyrene sulfonate (NaPSS) is a polyelectrolyte and its use as radiation dosimeter is not reported in literature. Therefore, the authors have investigated NaPSS as radiation dosimeter using thermally stimulated luminescence, electron spin resonance and Fourier transform infrared spectroscopic techniques.

Experimental

Sodium polystyrene sulfonate in powder form supplied by Pressure Chemicals, USA, is used in the present study. The sample is pressed into pellet for TSL studies. The sample holder is placed on thermocouple, which is heated with an intermediate heating rate of 10 °C/min. The sample holder is kept in front of the window of a photomultiplier tube to detect the luminescence emitted by the sample. The photo current is measured by a Keithley electrometer.

For ESR studies, the powder sample is irradiated with a Cobalt-60 gamma source with a dose rate of 15 K Gy/h in air at room temperature. ESR spectra of irradiated samples are recorded on VARIAN-E line spectrometer operating at X-band frequencies and 100 kHz frequency modulation. Dose administered to the sample is measured by time of irradiation. FTIR spectra of unirradiated and irradiated NaPSS are recorded on a Perkin-Elmer spectrometer by making the pellets of NaPSS with potassium bromide (KBr).

Results and Discussion

TSL spectra of un-irradiated and irradiated NaPSS are shown as curve1 and curve 2 in Figure 1. The spectra consists of a glow peak around 365 K. On irradiation, glow peak intensity increases with a little change in peak temperature. Initially the glow peak is thought to be associated with the glass transition point, based on the concept that the Tg of ploysterene (PS) homo-polymer has Tg in the same temperature range. However, Prasad [10] proved that the hypothesis is wrong based on the DSC studies. The observed DSC peak at 365oK is of second order and arises due to chemical modification but not due to glass transition. The observed TSL glow peak luminescence is thought to be associated with the release of traps facilitated by the thermal energy given by heating. Since the NaPSS is a polyelectrolyte containing electrical charges/ions, these charges are assumed to be released and recombined to give TSL peak. The remaining polymer chains form network structure on thermal heating.

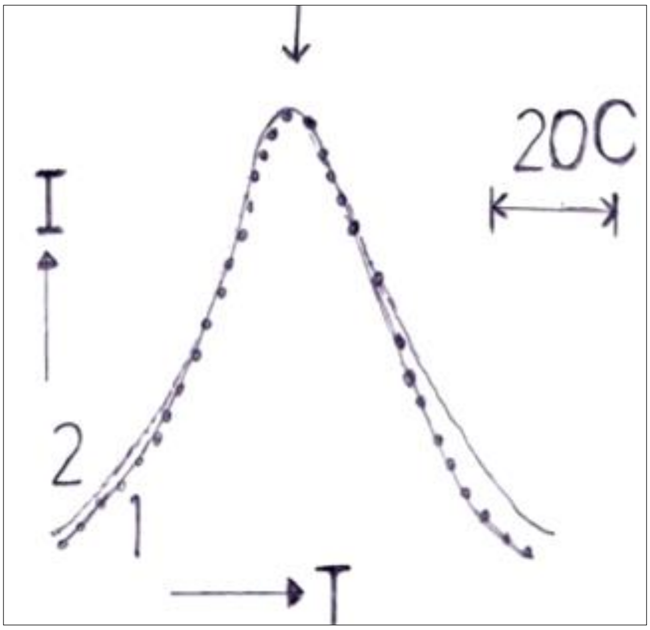

Fig 1: TSL Spectra of Unirradiated and Irradiated of NaPSS. Curve 1: Unirradiated NaPSS, Curve 2: Irradiated NaPSS.

TSL spectra are recorded for NaPSS irradiated different radiation doses. Variation of TSL intensity against radiation dose is as depicted in Figure 2. The figure shows excellent linearity, suggesting that NaPSS could be used for dosimetric applications.

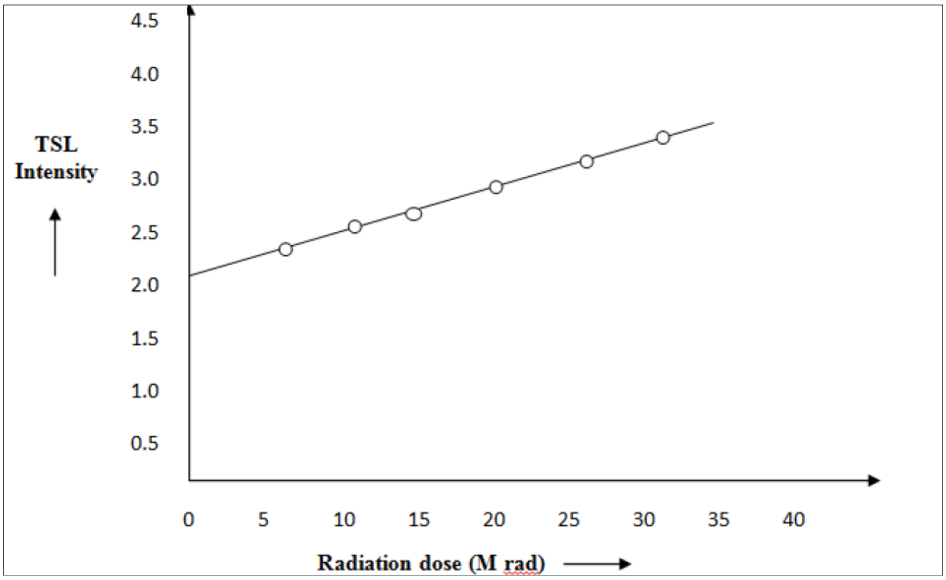

Fig 2: Variation of TSL Intensity against Radiation Dose.

ESR spectrum of NaPSS irradiated to 1 M rad dose is shown as curve 1 in Figure 3. Curves 2, 3, 4 and 5 represent the ESR spectra of NaPSS irradiated to 3, 6, 9 and 12 M.rad dose of irradiation. The spectra are almost singlets having no hyper fine structure. Free radicals formed in side chains of NaPSS irradiation are responsible for observed ESR spectra [11].

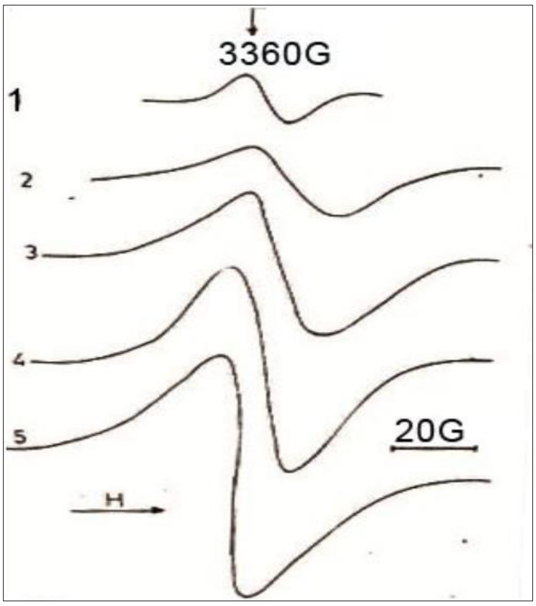

Fig 3: ESR Spectra of NaPSS Irradiated to Various Radiation Doses.

Intensities of ESR spectra are measured by double-integration methods [12] and plot is drawn between ESR intensity against radiation dose as shown in Figure 4. The curve also exhibits excellent linearity indicating that the NaPSS is fit for dosimetric applications.

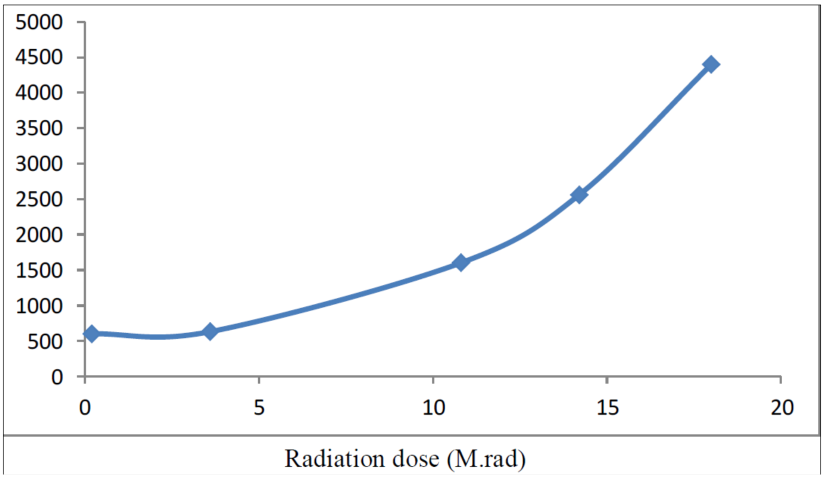

Fig 4: Variation of ESR Intensity against Radiation Dose.

FTIR spectrum of non-irradiated and irradiated NaPSS is shown in Figure 5. The spectra characterize various chemical groups of polymer. They include sulfonic acid groups, methylene groups, aromatic ring, etc. Every group gives its own characteristic absorption band at a particular position.

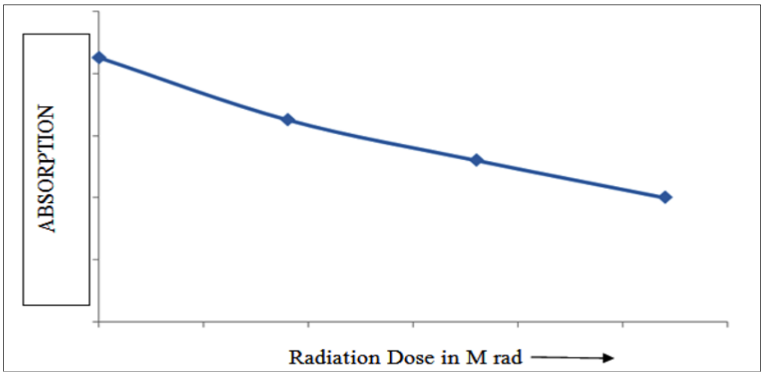

Fig 5: Variation of 1092 cm−1FTIR Absorption Band Intensity against Radiation Dose.

On irradiation, intensity of some of these groups is found to decrease. It is observed that the intensity of sulfonic acid group at the position 1092 cm−1 is more prone to gamma radiation. The figure also indicates excellent linearity with radiation dose and indicates dosimetric applications of NaPSS.

Conclusions

TSL, ESR, FTIR spectra of un-irradiated and irradiated NaPSS indicate that the spectral intensity linearly varies with radiation dose, suggesting that the polymer could be used for dosimetric applications within the given radiation dose limits.

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