i-SPiKE 2023

INTERNATIONAL EXHIBITION & SYMPOSIUM ON PRODUCTIVITY, INNOVATION, KNOWLEDGE & EDUCATION

"Optimizing Innovation in Knowledge, Education and Design"

EXTENDED ABSTRACT

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Assalamualaikum warahmatullahi wabarakatuh,

First and foremost, I would like to express my gratitude to the organizing committee of i-Spike 2023 for their tremendous efforts in bringing this online competition a reality . I must extend my congratulations to the committee for successfully delivering on their promise to make i-Spike 2023 a meaningful event for academics worldwide.

The theme for this event, 'Optimizing Innovation in Knowledge, Education, and Design,' is both timely and highly relevant in today's world, especially at the tertiary level. Innovation plays a central role in our daily lives, offering new solutions for products, processes, and services By adopting a strategic approach to 'Optimizing Innovation in Knowledge, Education, and Design,' we have the potential to enhance support for learners and educators, while also expanding opportunities for learner engagement, interactivity, and access to education.

I am awed by the magnitude and multitude of participants in this competition. I am also confident that all the innovations presented have provided valuable insights into the significance of innovative and advanced teaching materials in promoting sustainable development for the betterment of teaching and learning. Hopefully, this will mark the beginning of a long series of i-Spike events in the future.

It is also my hope that you find i-Spike 2023 to be an excellent platform for learning, sharing, and collaboration. Once again, I want to thank all the committee members of i-Spike 2023 for their hard work in making this event a reality I would also like to extend my congratulations to all the winners, and I hope that each of you will successfully achieve your intended goals through your participation in this competition.

Professor Dr. Roshima Haji Said
RECTOR
UiTM KEDAH BRANCH

WELCOME MESSAGE (i-SPiKE 2023 CHAIR)

We are looking forward to welcoming you to the 3rd International Exhibition & Symposium on Productivity, Innovation, Knowledge, and Education 2023 (i-SPiKE 2023). Your presence here is a clear, crystal-clear testimony to the importance you place on the research and innovation arena. The theme of this year's Innovation is "*Optimizing Innovation in Knowledge, Education, & Design*". We believe that the presentations by the distinguished innovators will contribute immensely to a deeper understanding of the current issues in relation to the theme.

i-SPiKE 2023 offers a platform for nurturing the next generation of innovators and fostering cutting-edge innovations at the crossroads of collaboration, creativity, and enthusiasm. We enthusiastically welcome junior and young inventors from schools and universities, as well as local and foreign academicians and industry professionals, to showcase their innovative products and engage in knowledge sharing. All submissions have been rigorously evaluated by expert juries comprising professionals from both industry and academia.

On behalf of the conference organisers, I would like to extend our sincere thanks for your participation, and we hope you enjoy the event. A special note of appreciation goes out to all the committee members of i-SPiKE 2023; your dedication and hard work are greatly appreciated.

Dr. Junaida Ismail

Chair
3rd International Exhibition & Symposium Productivity, Innovation, Knowledge, and Education 2023 (i-SPiKE 2023)

SUSTAINABLE SAP HYDROGELS ENHANCE CONTROLLED UREA RELEASE IN AGRICULTURE

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ABSTRACT

Hydrogels offer unique advantages in agriculture due to their water-retention properties and ability to swell when in contact with water. This study focused on exploring the slow-release capabilities of Super Absorbent Polymer (SAP) hydrogels, particularly in efficiently absorbing urea fertilizer. The researchers developed a nitrogen-based slow-release fertilizer using urea-impregnated hydrogel structures, analyzed through Fourier Transform Infrared (FTIR) analysis. The findings highlight the potential of hydrogel integration in agriculture as an effective technique for self-planting, especially in modern farming. Hydrogels' gradual nutrient release addresses challenges of nutrient leaching and loss, enhancing nutrient availability for plants. Additionally, their water-retention abilities support proper irrigation and reduce water wastage, promoting sustainable water management. Beyond improved crop growth, hydrogel integration bears implications for community economic management. By potentially increasing crop yields, conserving resources, and reducing input costs, this eco-friendly and economically viable approach can pave the way for more sustainable and productive farming practices.

Keywords: Agriculture; nutrient uptake; slow-release; super absorbent polymer hydrogel; water retention

INTRODUCTION

Global food security faces challenges from rising demand and limited resources, requiring solutions for growing populations within environmental limits (Jambo et al. 2021). Threats like increased consumption, water scarcity, and climate change impact agriculture and the economy significantly (Kidani and Kejela, 2021; Wang 2022). Alternative agricultural systems have evolved to ensure sufficient food quantity and quality, with planting mediums playing a vital role in nutrient supply and seedling development (Abdallah, 2019). Maximizing profits and yield remains challenging in water-limited areas . Food insecurity and undernutrition persist as critical issues, and urban farming technology strengthens the agriculture sector (Utmale et al. 2020). Urban farming in developing countries enhances food security by supplying fresh produce to city markets through numerous urban farmers (Orsini et al. 2013). Water-conserving methods are crucial in combating water and nutrient loss risks and alleviating plant moisture stress. Therefore, in response to water scarcity and environmental concerns, biodegradable hydrogels have gained interest in agriculture. These water-absorbing polymers can enhance soil water absorption in arid areas through water absorption and desorption capabilities.

Hydrogels find applications in agriculture, biosensors, wound dressing, regenerative medicine, tissue engineering, and more, significantly contributing to improved agricultural practices. In agriculture, fertilizers play a crucial role in crop production. However, a significant challenge arises as more than half of commonly used fertilizers are lost due to rain and irrigation runoff. This leads to economic losses and environmental pollution. Slow-release fertilizers (SRFs) offer a solution by releasing nutrients gradually, matching plant needs and minimizing losses. SRFs address both economic and environmental concerns effectively.

However, A significant proportion of nitrogen (approximately 40-70%), phosphorus (around 80-90%), and potassium (roughly 50-70%) in common fertilizers is lost to the environment without proper plant absorption. Urea fertilizer, acting as a nitrogen source for plants, stimulates leaf development, and enhances their appearance. While widely used in agriculture, urea hydrolyzes rapidly in the soil through urease, releasing ammonia and carbon dioxide, leading to nitrogen loss through ammonia volatilization. Depending on environmental and soil conditions, over 40% of applied nitrogen can be lost as ammonia (Singh et al., 2013; Sun Ruibo et al., 2019).

Therefore, the main objective of this study was to investigate the optimization of fertilizer absorption, with a specific focus on urea as a nitrogen-based fertilizer. The primary analytical technique used was Fourier Transform Infrared (FTIR). The research involved examining urea uptake concerning factors like urea concentration, optimal temperature, pH conditions, and conducting a kinetic analysis.

METHODOLOGY

2.1 Materials

Potassium polyacrylate-based super-absorbent polymer (SAP) hydrogels in granular form were procured from Zhong Ma Chemicals. These hydrogels were obtained in a dried state and appeared white. Urea, used as the nitrogen-based fertilizer, was purchased from HmBG Chemicals. The soil used in the biodegradability test was acquired from a nearby local store.

2.2 Preparation of Hydrogels

The preparation of hydrogels involved two methods. In the first method, super-absorbent polymer (SAP) hydrogel granules were used in their dry form as received. In the second method, hydrogels were soaked in distilled water for 24 hours, causing them to swell. Afterward, the swollen hydrogels were sliced into dimensions of 1 cm x 1 cm x 1 cm for subsequent experiments.

2.3 Study on Urea Uptake

The study on fertilizer uptake by super-absorbent polymers (SAP) focused on four variables: concentration, temperature, pH, and time (kinetic study). Urea solutions of 15%, 30%, and 45% were examined for various urea concentrations. Temperature's influence was studied at 20°C, 40°C, and 60°C, using a 45% urea solution (based on a prior study). Additionally, the pH study adjusted a 45% urea solution at 60°C to pH levels of 4, 7, and 9.

$$\text{Urea solution uptake (\%)}: [(W_f - W_i)/ W_i] \times 100\% \quad (1)$$

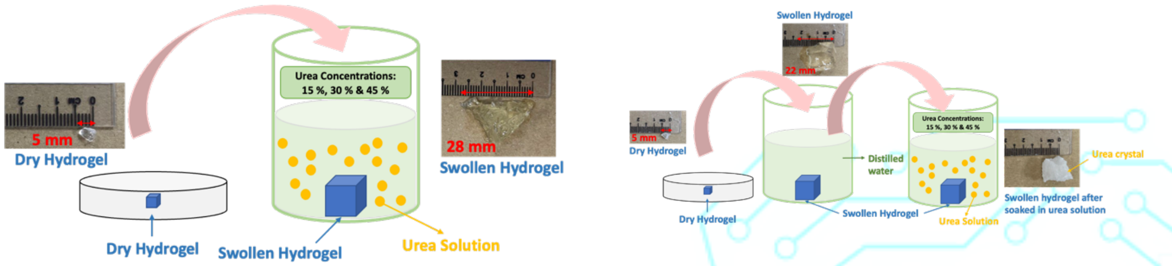
where W_f is the final weight of hydrogel after immersed in urea solution, W_i is the initial weight of hydrogel before immersing, respectively.

Concurrently, a kinetic study was performed using the optimized urea solution concentration, temperature, and pH. The immersion time intervals were set at 0.5, 1, 2, 3, 4, 5, 6, 12, 24 and 36 hours. At each interval, a hydrogel sample was extracted, and the urea solution uptake was measured using Equation 1 until equilibrium was reached. Subsequently, the samples were removed from the urea solution, dried using filter paper, and weighed.

Results And Discussion

3.1 Effect of Hydrogels Preparation

In comparison to the dry hydrogel preparation method, the dry hydrogel demonstrated a higher urea solution absorption capacity, absorbing 27981% of the solution, while the swollen hydrogel could only absorb 366% of the urea solution. The ability of dry hydrogels to absorb urea solution is typically better compared to swollen hydrogels due to increase swelling capacity. Dry hydrogels have a higher capacity for swelling compared to already swollen hydrogels. This is because the internal structure of dry hydrogels is relatively unimpeded, allowing them to expand and absorb more liquid. Meanwhile, Figure 1(a) and Figure 1(b) show the preparation method of hydrogels before undergoing urea solution uptake at different concentration for dry and swollen hydrogel and their physical appearance. As can be seen in Fig. 2(b), when swollen hydrogels are soaked in urea solution, after the soaking period, urea crystals stay on the surface of hydrogels. This indicates that the urea does not diffuse into the hydrogels structure.



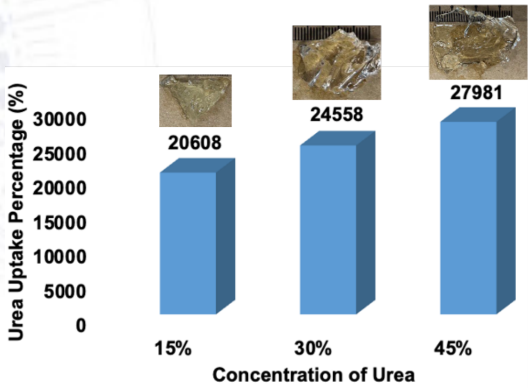
(a) (b)

Figure 1. Method of preparing hydrogels for urea solution uptake test (a) direct from dry hydrogels and (b) swollen hydrogels

3.2 Study of Urea Solution Uptake Performance

3.2.1 Effect of Urea Concentration

Figure 2 presents the urea uptake percentages at various urea concentrations. Lower urea concentrations showed higher urea solution uptake compared to higher concentrations, attributed to reduced osmotic pressure differences between the hydrogel network and external urea solution (Youxin et al. 2021). It is depicts that physical appearance of dry hydrogels and hydrogels soaked at different urea concentrations, showing transparent swollen hydrogels with size variations corresponding to urea solution uptake—higher percentages resulting in larger, more swollen hydrogels. When a hydrogel is immersed in a urea solution, urea molecules penetrate the hydrogel network and interact with polymer chains, disrupting hydrogen bonding between them. This reduces intermolecular forces, making the hydrogel network more flexible



and facilitating increased water uptake.

Figure 2. Urea solution uptake and their physical appearance of SAP hydrogels

3.2.2 Effect of Temperature of Urea Solution

Investigation of urea solution uptake at different temperatures has been conducted, however the is shows that urea solution at 40 °C and 60 °C has turned into urea crystals as can be seen in Figure 3. Meanwhile, the swollen hydrogel in the solution also was covered with urea crystals at elevated temperature of 40 °C and 60 °C and at the same time limits their swelling ability (Warunee Tanan et al., 2021; Jate Panichpakdee et al., 2021; Pitchayaporn Suwanakood et al., 2021; Sayant Saengsuwan et al., 2021). This happen due to the urea's solubility in water is highly temperature dependent. As the temperature increases, the amount of urea that can dissolve in water decreases. This decrease in solubility is due to changes in the thermodynamic properties of the system, including changes in the enthalpy and entropy of dissolution. At temperatures above a certain point, known as the solubility limit, the urea molecules are no longer able to stay in solution and begin to precipitate out as crystals. Therefore, at 40 and 60 degrees Celsius, the solubility of urea is lower compared to a lower temperature. As a result, if a urea solution is heated to 40 or 60 degrees Celsius, the concentration of urea in the solution can exceed its solubility limit, causing the excess urea to crystallize and form solid particles or crystals.

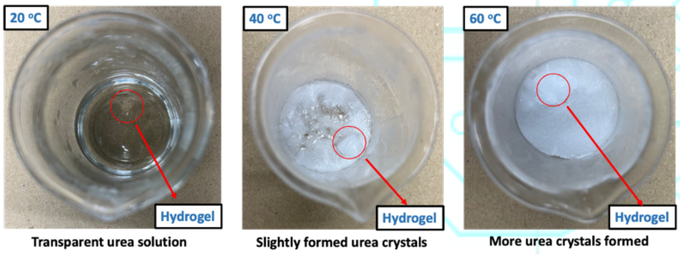


Figure 3. Swollen hydrogels soaked at different temperature of 45% urea solution

3.2.3 Effect of pH of urea solution

Figure 4 presents the swelling behavior of hydrogels concerning the pH of the surrounding environment. The results show that at pH 4.0, the urea solution uptake was 470%, which increased to 804% at pH 7.0. However, at pH 9.0, the uptake reduced significantly to 271%. Hydrogel swelling occurs as water molecules diffuse into the network through interactions with functional ionic groups, while electrostatic repulsion between polymer chains leads to increased sample dimensions, resulting in swelling. In the pH range of 6.5 to 7.5, carboxylic acid groups experience slight ionization, leading to elevated repulsive forces between carboxylate anions and increased hydrogen bonding, enhancing water uptake. However, at pH 9, water uptake decreases due to the formation of carboxylate anions, reducing electrostatic repulsion in the network

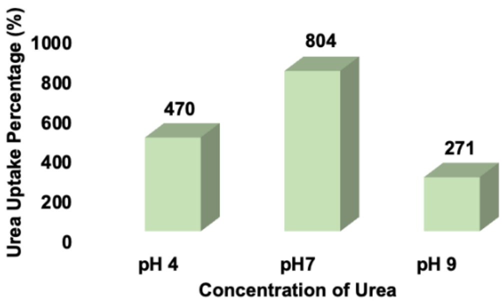


Figure 4. Urea solution uptake in different pH

3.3 Kinetic Study

In Figure 5, the kinetics study on urea solution uptake is presented. It demonstrates a rapid increase in uptake during the initial 5 hours, followed by a slower increase from 5 hours to 15 hours. After 24 hours of soaking time, the uptake reaches equilibrium. When cellulose hydrogel encounters water and a urea solution, it swells due to osmosis. Osmosis drives water molecules from lower to higher solute concentration through the cellulose hydrogel acting as a semipermeable membrane. The urea solution's higher solute concentration attracts water molecules from the surroundings into the hydrogel. Cellulose's hydrophilic nature allows it to absorb and retain water, leading to the hydrogel's gradual expansion. The extent of swelling depends on water absorption through osmosis, with longer immersion resulting in more significant swelling. Specific hydrogel properties, such as composition, cross-linking, and molecular structure, affect swelling behavior. Overall, osmosis causes the cellulose hydrogel to increase in size when soaked in water and a urea solution (Tammy L. Sirich et al., 2016).

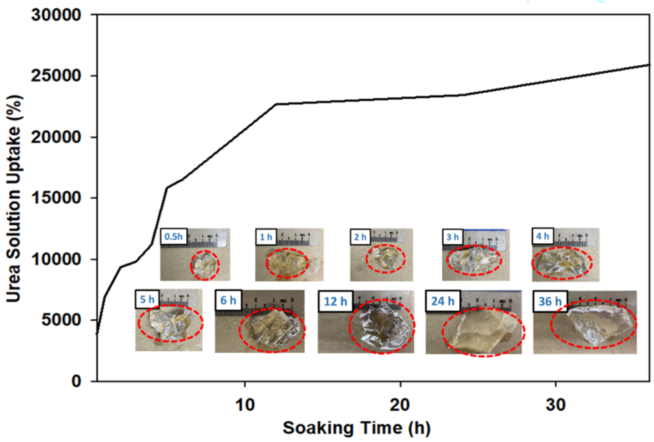


Figure 5. (a) Kinetics study of urea solution uptake

CONCLUSION

A hydrogel should be absorbed at a rate of 45% of the concentration of urea solution. The hydrogels' mass required to absorb the urea solution grows by 1 g every hour. The temperature test revealed that room temperature (24°C) resulted in a more effective hydrogel absorption process for the urea solution.

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