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# Appendices

## Appendices

I. Development of Vis-NIR sensor

i. AS7265x:

The most basic Triad Spectroscopy Sensor from Sparkfun, commonly known as a Spectrophotometer, is the AS7265x (Fig. i). Three sensors, designated AS72651, AS72652, and AS72653, combine to create the sensor. For detecting the visible light spectrum, use AS72651. AS72652 is used to measure UV light similarly. An IR sensor for sensing IR radiation is the AS72653. Additionally, the sensor features a 4 Mbit EEPROM that the system's firmware loads. At power-up, the AS72651 reads the EEPROM. From 410 nm to 940 nm, the AS7265x Triad Spectroscopy Spectral Sensor can detect light. The sensor can detect up to 18 different light frequencies. The sensor has three distinct LEDs: a white LED (5700K), an ultraviolet LED (405nm), and an infrared LED (875 nm). These LEDs' primary function is to illuminate the intended item with the broadest possible beam of visible or invisible light. The sensor runs at 3.3V, which is the usual voltage. The sensor has SDA (Serial Data) and SCL (Serial Clock) I2C connections.

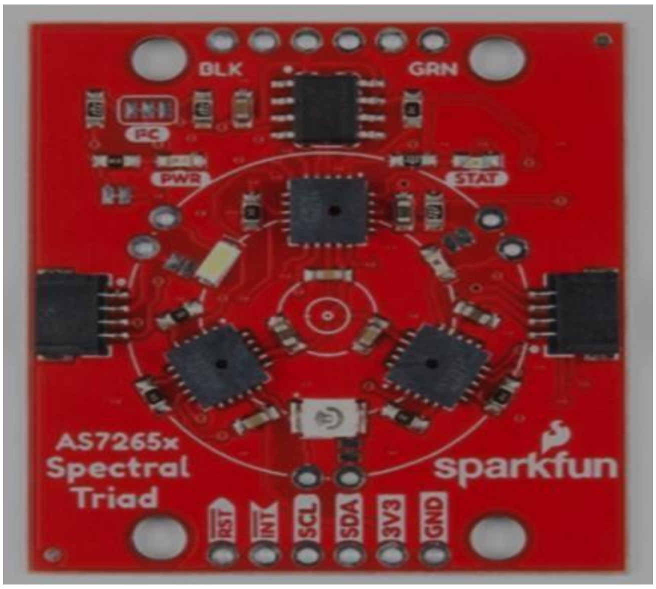


**Fig. i: AS7265x**Arduino Mega 2560:

An ATmega 2560-based microcontroller board is called the Arduino Mega 2560 (Fig. ii). It contains 16 analogue inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, 54 output pins and digital inputs (15 of which can be used as PWM outputs), a USB connector, a power jack, an ICSP header, and a reset button. Either an external power source or the USB connection can be used to power the Arduino Mega 2560. The Arduino Mega's I2C pins use a two-wire serial interface. Inter-Integrated Circuits is the abbreviation. A serial clock pin (SCL) and a serial data pin (SDA) are used by the I2C for sending and receiving data, respectively. The line that transmits clock data is known as the SCL (Serial Clock). The line that transmits and receives data is referred to as SDA (Serial Data). That is why SCL is referred to as a clock line while DSL is considered a data line. The Arduino Mega Board can be powered in three different ways: 1. Barrel jack - Our Arduino board may be powered by the barrel jack, also known as the 7-12V DC Power Jack. Typically, an adapter is connected to the barrel jack. The manufacturer advises keeping the voltage between 7 and 12 volts, but the circuit boards can be fueled by an adaptor that runs between 5 and 20 volts. The board can become hot at voltage levels above 12 volts, and it may not be able to function at voltage levels below 7 volts. 2. USB B-port—The USB Interface is where the USB cable is plugged in. This connection enables us to join the board to the computer and can be utilized for powering the gadget from a 5V supply. Through the USB cable, the computer serially uploads the program to the board. 3. Vin-It, which is used to control the ICs in the connection, is the modulating DC supply voltage. For the ICs included on the Arduino board, it is also known as the primary voltage. To the GND pin, the VCC voltage value might be either positive or negative.


**Fig. ii: Arduino Mega 2560**

A.II Color mapping of concentration of water radially along the polar coordinates

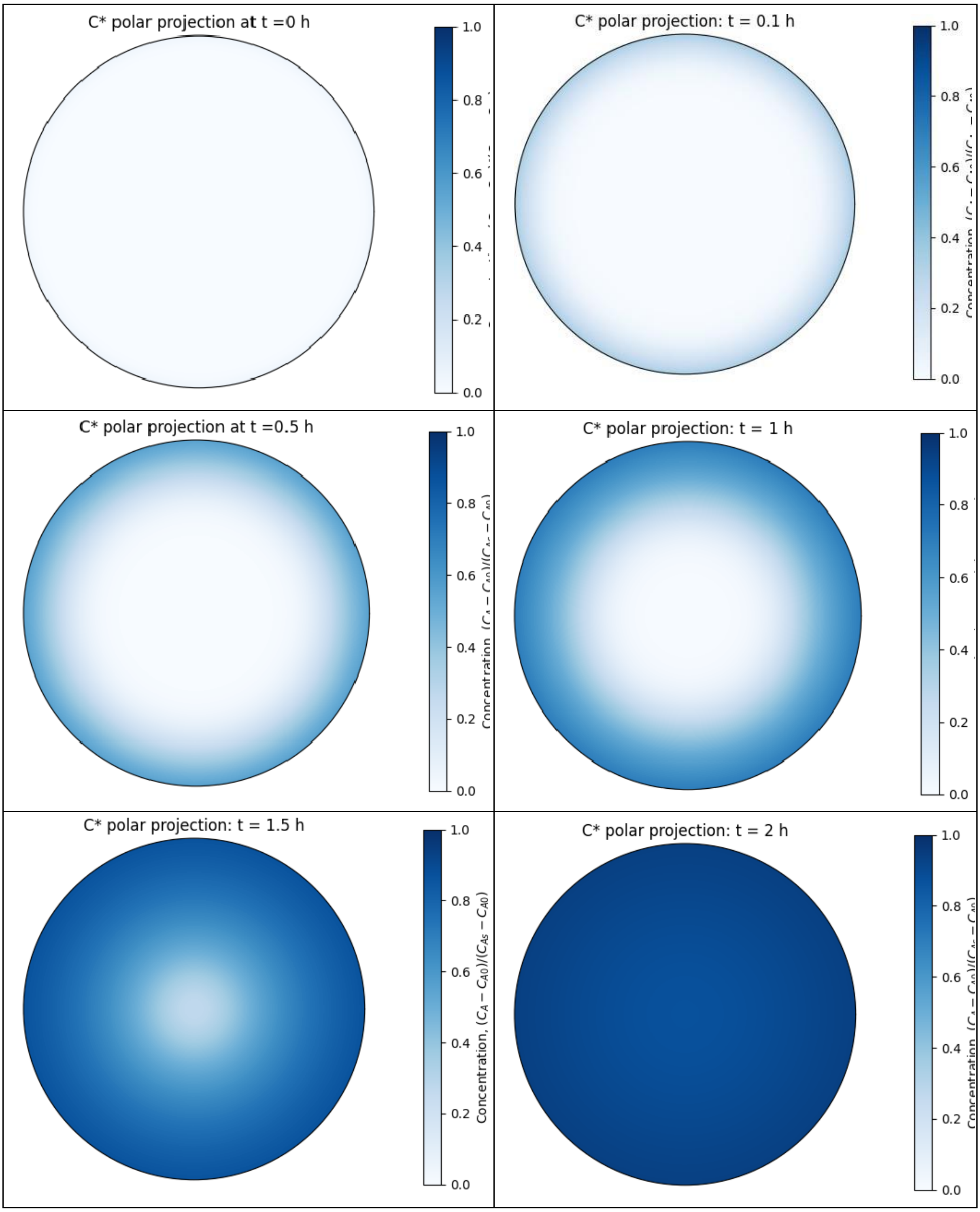


**Fig iii: Color mapping of concentration of water radially along the polar coordinates from surface to core at 50 ℃**

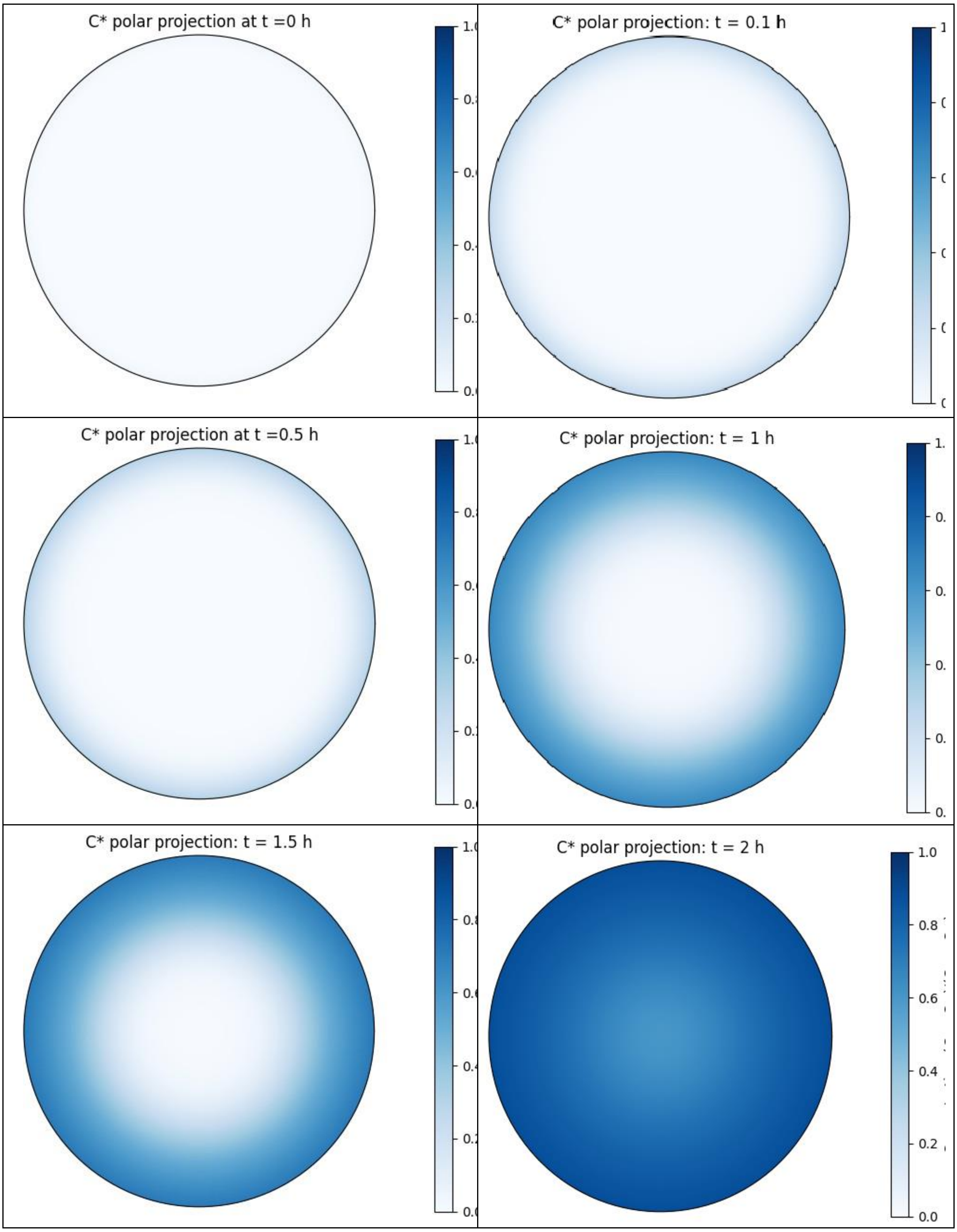


**Fig iv: Color mapping of concentration of water radially along the polar coordinates from surface to core at 40 ℃**

A.III Gruel solid loss

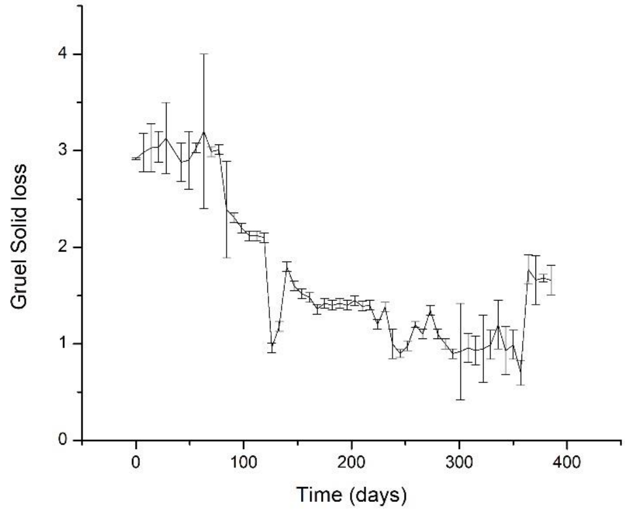


**Fig v: Change in Gruel solid loss of *Komal Chaul* with respect to storage time**

A.IV RVA profiles for the storage temperature study

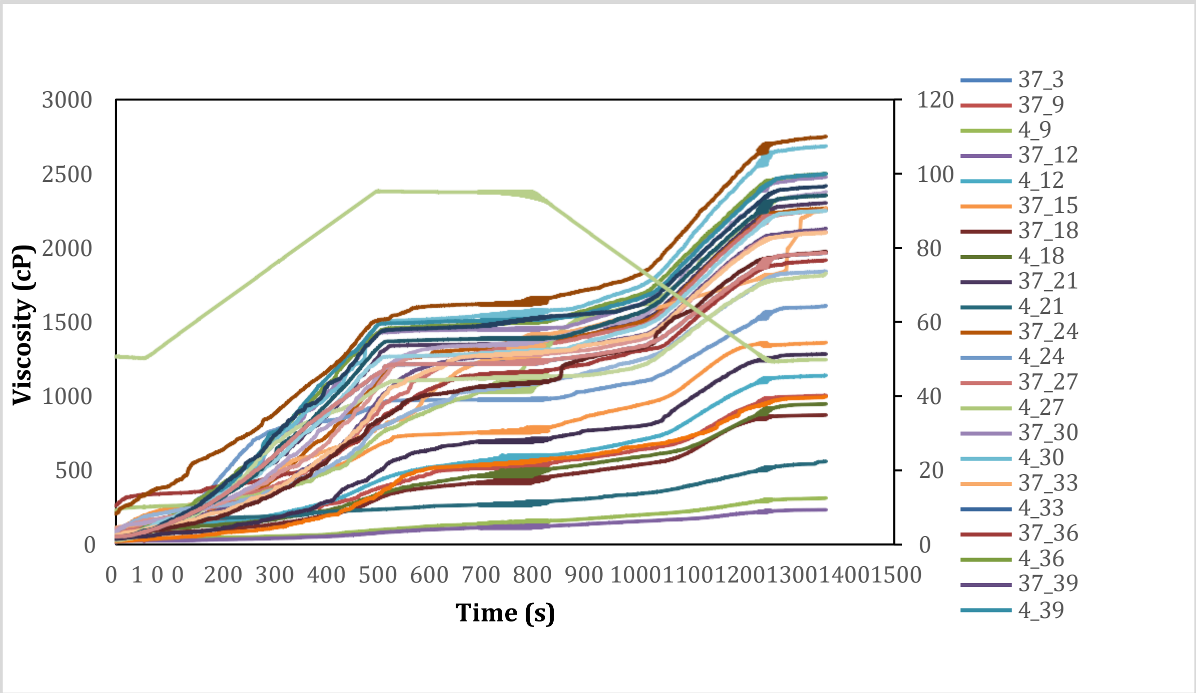


**Fig vi: RVA plot for the storage temperature study**

A.V Diffusion equation prediction plots

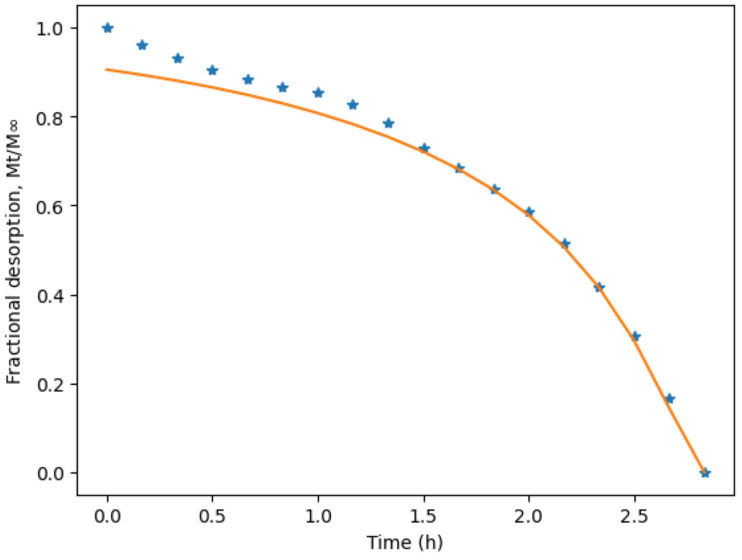


**Fig vii: Diffusion equation prediction plot at temperature 50 °C for drying**

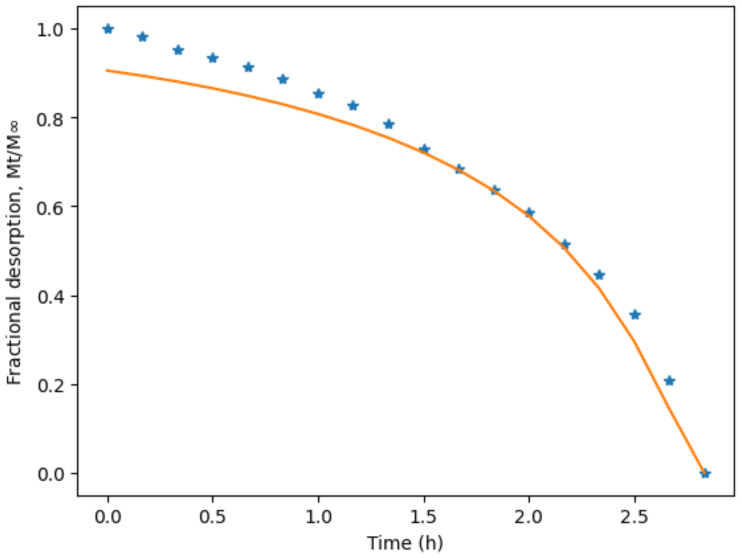


**Fig viii: Diffusion equation prediction plot at temperature 40 °C for drying**

A.VI Mass diffusivity with respect to time at different temperature during drying

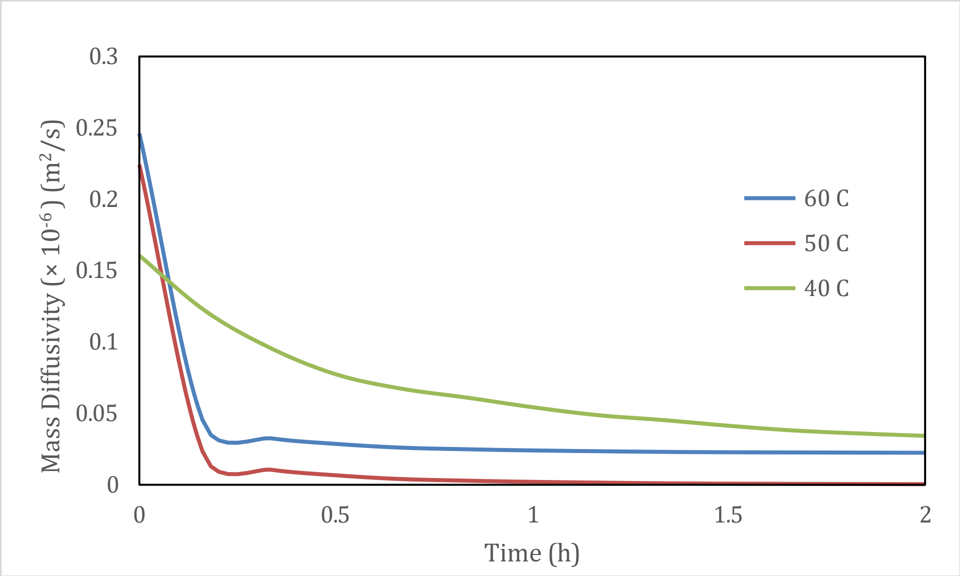


**Fig ix: Mass diffusivity with respect to time at different temperature**

A.VII Instantaneous Control Pressure Drop (ICPD) set up.


**Fig x: ICPD for steaming process**

A.IX Reflectance values against wavelength for drying process

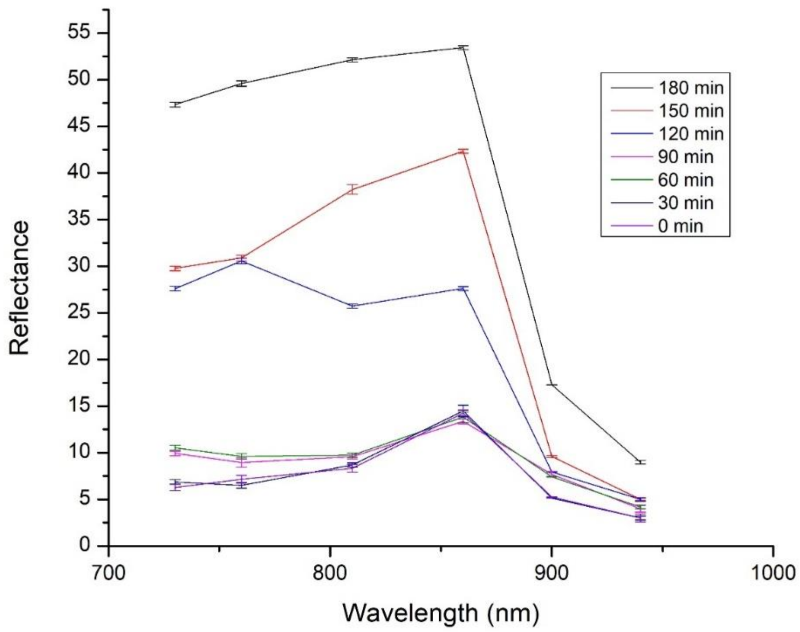


**Fig xi: Reflectance values against wavelength for drying process at 60°C**

A.X Validation of solution to diffusion equation with separate test data

The diffusion equation was solved using Hsu model for the process of drying and soaking. As an example, the experimental data was divided into 50% training data and 50% test data and also 67% and 33% training and test data. The average effective diffusivities were calculated using the test data and RMSE values for the revised prediction of volumetric concentration shown in Table i.

**Table i: Showing the performance of the diffusion equation (Hsu model) for prediction of volumetric concentration during drying**

| **Temperature of Data set (°C)** | RMSE of volumetric concentration($kg/m^3$) | | | |
|---|---|---|---|---|
| | **For 50% training data and 50% test data** | | **For 33% of training data and 67% of test data** | |
| | Training data set | Testing data set | Training data set | Testing data set |
| 40 | 1.3075 | 2.2854 | 0.3764 | 2.0020 |
| 50 | 1.5814 | 2.2396 | 1.0369 | 1.9016 |
| 60 | 1.9875 | 2.3810 | 0.4674 | 2.4710 |

For references, the plots for fractional moisture absorption and desorption's fitting at 60 °C is shown.

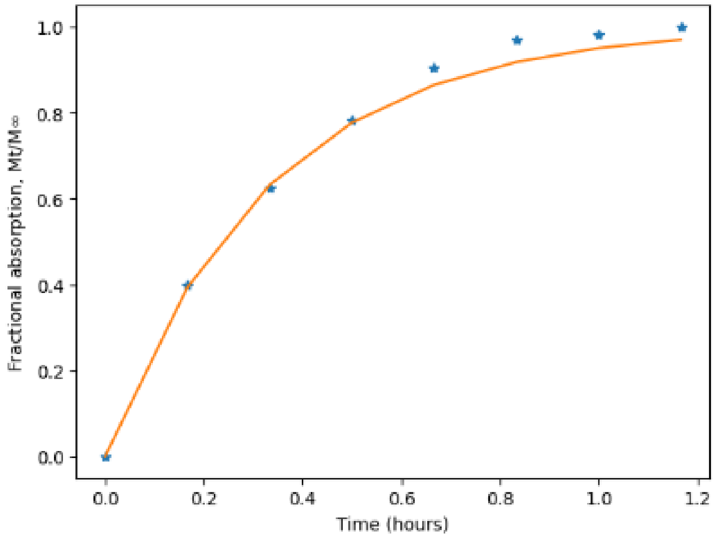


**Fig xii: Diffusion equation (Hsu model) prediction plot at temperature 60 °C for soaking**

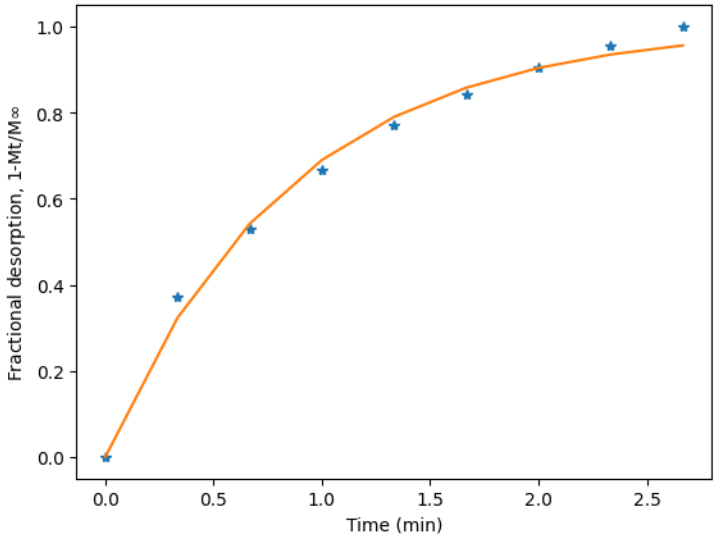


**Fig xiii: Diffusion equation prediction (Hsu model) plot at temperature 60 °C for drying**

A.XI Drying time calculation

**Table ii: Table showing the calculation of Page's equation for time estimation**

| T (°C) | $M_e$ | MR | k | n | 1/n | ln(MR) | ln(MR) /(-k) | Time (min) |
|---|---|---|---|---|---|---|---|---|
| 60 | 0.1027 | 0.0950 | 0.0693 | 0.702 | 1.4245 | -2.3537 | 33.9645 | 151.6866 |
| 50 | 0.1124 | 0.0766 | 0.0694 | 0.708 | 1.4124 | -2.5687 | 37.0133 | 164.1327 |
| 40 | 0.1237 | 0.0543 | 0.0695 | 0.715 | 1.3986 | -2.914 | 41.9284 | 185.8842 |

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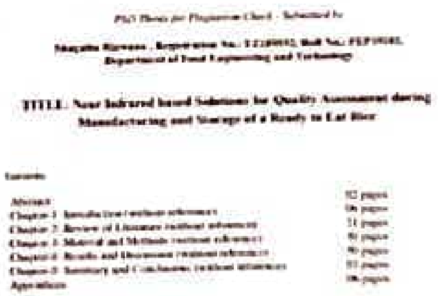

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