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(Research Article)

Round The Clock Juice Concentration, Using Juice Electrolysis, Generated By Solar Cells of Solar Panel under Influence of Solar Energy and Fiber Optics

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Abstract

Juice concentrates are made by extracting water from freshly squeezed juice. Extracting water from fresh juice today is done by evaporation, freezing of the water, or using diaphragms. The article presents a round-the-clock concentration of freshly squeezed juice, using electrolysis of the water component of freshly squeezed juice, generated by direct electric current from sunlight from a light receiver transmitted via optical fiber to a solar panel element, resulting in the formation of negatively charged microdispersed electrolytic bubbles of hydrogen and obtaining a high-quality concentrate of fresh juice by flotation of microsolid components of freshly squeezed juice with these bubbles.

Round-the-clock concentration of freshly squeezed juice in a specially designed electroflotator is achieved by using sunlight from a light receiver, transmitted via optical fiber as light for the solar panel element, and a light-emitting diode (LED) with a battery charged during the day by parallel connection with a working solar panel element, which begins to illuminate the solar panel element in the absence of sunlight at night until the battery is completely discharged in the morning, and continuously filling the electroflotator with freshly squeezed juice.

Keywords: Concentrates of juice; solar cells of a solar panel; fiber optics; electroflotator; hydrogen electrolytic gas bubbles; silicon semiconductor; solar energy; LED.

1. Introduction

Freshly squeezed juice contains water, which combines valuable microscopic particles of sucrose, sugar and acid. Concentration of freshly squeezed juice is the extraction of water from freshly squeezed juice.

There are the following methods for concentrating freshly squeezed juice: by evaporation, freezing of water or using diaphragms.

During the evaporation process, freshly squeezed juice is heated in a vacuum below the boiling point to preserve all the useful substances [1-4].

During the freezing process, water is removed by cold [5, 6]. When using diaphragms, freshly squeezed juice is passed through a membrane with tiny cells, as a result of which water penetrates through the membrane, and large molecules of freshly squeezed juice concentrate settle on the membrane [1-4].

All these methods are quite complex and require large economic costs.

The article presents a round-the-clock concentration of freshly squeezed juice, using electrolysis of the water component of freshly squeezed juice, generated by direct electric current from sunlight from a light receiver transmitted via optical fiber to a solar panel element, resulting in the formation of negatively charged microdispersed electrolytic bubbles of hydrogen and obtaining a high-quality concentrate of fresh juice by flotation of microsolid components of freshly squeezed juice with these bubbles

Round-the-clock concentration of freshly squeezed juice in a specially designed electroflotator is achieved by using sunlight from a light receiver transmitted via optical fiber as light for the solar panel element, and a light-emitting diode (LED) with a battery charged during the day by parallel connection with a working solar panel element, which begins to illuminate the solar panel element in the absence of sunlight at night until the battery is completely discharged in the morning, and continuously filling the electroflotator with freshly squeezed juice.

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2. Materials and Methods

The developed by authors concentration of freshly squeezed juice, using electrolysis of water component of freshly squeezed juice, generated by direct electric current from sunlight from a light receiver, transmitted via optical fiber to a solar panel element and a specially developed electroflotator-concentrator, were tested at the Ganir plant (Israel). Squeezed juices of different plants were used: orange, apple and mango.

3. Theoretical and Experimental Research

The developed by authors concentration of freshly squeezed juice, uses the electrolysis of freshly squeezed juice, generated by direct electric current from sunlight from a light receiver, transmitted via optical fiber to a solarcell of a solar panel.

The sunflower-shaped solar radiation receiver is a device that includes 36 Fresnel lenses that rotate uniformly around their axis inside the receiver, following the sun throughout the day (Figure 1, [7]).Dynamic tracking of the solar light activity is carried out, using a built-in photo sensor, a microprocessorand motors, the total power consumption of which does not exceed 10 W.

The light receiver is assembled for 6000 lumens. The light receiver is installed on the roof of the room. The sunlight collected during the day is transmitted via optical fiber as light for the solar panel element, which provides the electroflotator with direct current. Optical fiber is a thin glass thread of circular cross-section [8 - 14]

Figure 1. A system that transmits sunlight through optical fiber

Solar panels [15-17] operate on the basis of a special solar photomodule, which includes solar cells that capture solar energy and convert it into a DC electric current, using silicon semiconductors.

The solar cell in turn consists of two joint layers of silicon, doped with phosphorus, which has four electrons in the outer orbit and, when combined with phosphorus, acquires five more electrons and, thus, nine electrons are formed in the common outer joint orbit of silicon, and, therefore, one unpaired electron will be extra, easily separated from the doped silicon under external influences - an N-type (negative) silicon layer, since the total number of electrons in the common outer joint orbit of silicon and phosphorus should be eight and legated with boron, which adds only three electrons to the four electrons in the outer orbit of silicon, and thus there will be seven electrons in the common outer orbit instead of eight and, therefore, one free space called a “hole” is freed up (P-type silicon layer(positive).

The generation of the electrolysis process of freshly squeezed juice, using solar cells of a solar panel powered by solar energy is carried out as follows.

When a solar cell of a solar panel is exposed by a solar ray, the “excess” electrons of the N-type silicon layer, due to their proximity to the “holes,” begin to combine through the N-P junction with the “holes” of the P-type silicon layer.

As a result, the border region of the N-type layer, due to the fact that a small part of the electrons goes into the region of the P-type layer, turns out to be partially positively charged, and most of the electrons “knocked out” by solar energy in the N-type layer move freely throughout the entire layer N-type.

The border region of the P-type layer turns out to be partially negatively charged, while the majority of unoccupied “holes” move freely in the general region of the P-type layer (Figure 2).

If electrodes (cathode and anode) are connected to the outer N-type layer and the following outer P-type layer, then two oppositely charged poles will appear on the electrodes: minus on the cathode, plus on the anode, which will lead to the creation of a potential difference. If the electrodes are connected to an electrical circuit, the load of which will be an electroflotator for concentrating freshly squeezed juice, then in the process of flowing direct electric current through the freshly squeezed juice between the electrodes, the process of electrolysis of freshly squeezed juice in the electroflotator is generated (Figure 3).

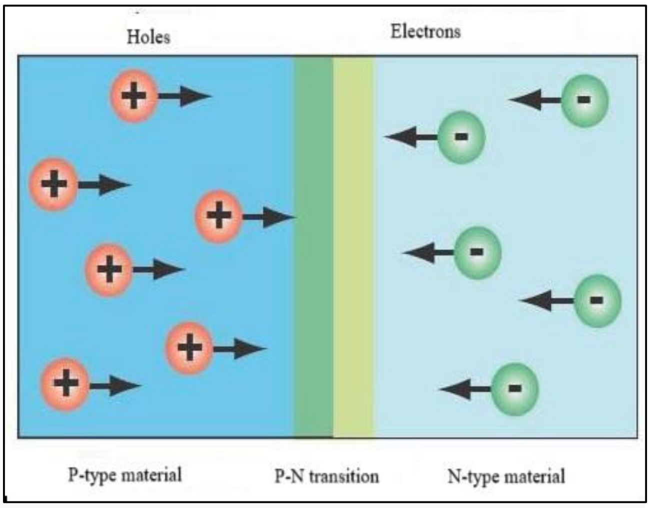

Figure 2. Electron-hole P-N junction and free movement of electrons and holes

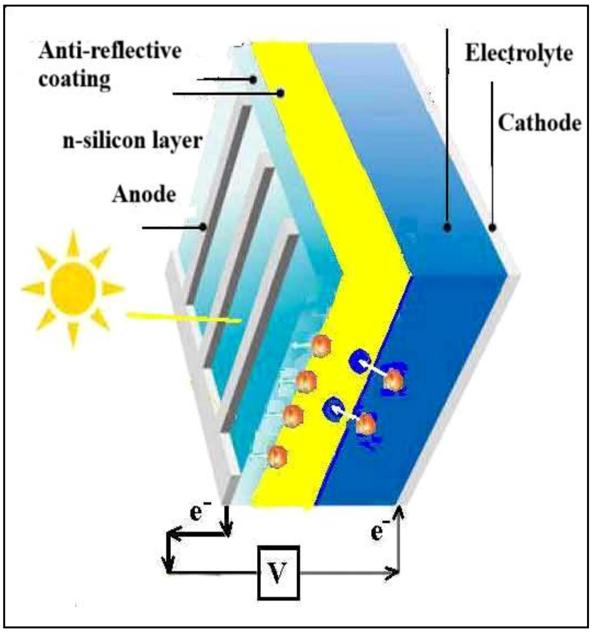

Figure 3. Solar cell operation

The round-the-clock supply of direct current voltage to the electrodes of a specially designed electroflotator is achieved by using sunlight from a light receiver transmitted via optical fiber as a backlight for the solar panel element, and a light-emitting diode (LED) with a battery charged during the day, by parallel connection with a working solar panel element, which begins to illuminate the solar panel element in the absence of sunlight in the room at night until the battery is completely discharged in the morning, and continuously filling the electroflotator with freshly squeezed juice.

The principle schema of LED control board will look as shown on Figure 4. The current, generated by solar panel sell, through diode D1 charges the battery (A).

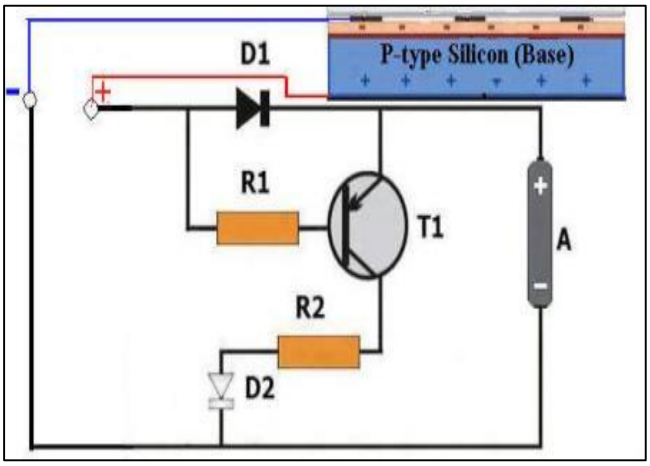

Figure 4. The principle schema of the LED light control board

The positive potential, applied to the base through resistor R1 “holds” transistor T1 in the off state and LED D2 does not light up. With a significant decrease of illumination of the solar panel sell, the transistor opens (due to a decrease in the positive potential, applied to the base) and connects LED D2 to the battery.

The LED starts to light up, illuminating the solar panel cell. Diode D1 prevents the battery from discharging during the light illumination.

When the light illumination is turned on, the positive voltage coming from the "+" output of the solar panel cell to the base "closes" transistor T1 and LED D2 stops glowing, and the battery starts charging.

In the developed method of concentrating freshly squeezed juice during the electrolysis of the aqueous component of freshly squeezed juice in an electroflotator, microdispersed electrolytic hydrogen bubbles are formed that have a negative charge, are uniform in size, are slightly prone to sticking together after separation from the cathode and maintain a constant diameter during the time they remain in the environment of freshly squeezed juice [18].

The formed negatively charged microdispersed electrolytic hydrogen bubbles, floating to the free surface of freshly squeezed juice, meet on the their way solid microparticles of sucrose, sugar and acid, the size of which is much larger than the size of microdispersed hydrogen bubbles, induce a positive charge on the outer surface of the microparticles and, due to the resulting force of electrostatic attraction opposite charges and surface tension forces, acting in one direction, are fixed on the surface of solid microparticles, forming strong foam from microdispersed hydrogen bubbles and solid microparticles of sucrose, sugar and acid, the lifting volume of which increases sharply and, due to the increased force of Archimedes, the foam accelerates to the free surface of the freshly squeezed juice electroflotator.

Figure 5 schematically shows the design of the developed electroflotator-concentrator, the round the cljck powered by a solar cell of a solar panel, and the principle of its operation in the process of continuous concentrating freshly squeezed juice.

A structurally designed electroflotator-concentrator for the round the clock, continuous concentration of freshly squeezed juice, powered by direct electric current from the solar cell of the solar panel -1 through electrodes, connecting the negative electrode of the N-type silicon semiconductor layer -2 with the cathode terminal of the electroflotator-concentrator, located on a special plug device, connecting external leads with the electrodes of the electroflotator-concentrator and the positive electrode of the P-type silicon semiconductor layer - 3, has a flotation chamber - 6, made in the form of a rectangular container, the corners of which are equipped with special inserts, as a result of which the inner part of the chamber takes the shape of a cylinder, and the rear upper partthe wall is equipped with a reflector.

The main element of the developed electroflotator-concentrator is the electrolysis base-12, connected to the solar cell of the solar panel with a special plug device and containing a special mechanism, made from non-conducting material, installed on the cathode, which allows simply adjusting the size of the inter electrode gap.

During the concentration process, freshly squeezed juice enters to the flotation chamber - 6 through a pipe with a valve 4, a pocket 5 and a slot 7.

When DC voltage is applied to the electrodes of the electrolysis base, occurs the electrolysis of water component of freshly squeezed juice water, intensively generating negatively charged microdispersed electrolytic hydrogen bubbles, which, floating to the free surface of the freshly squeezed juice electroflotator, encounter in their path solid microparticles of sucrose, sugar and acid, the size of which is much larger than the size of microdispersed hydrogen bubbles.

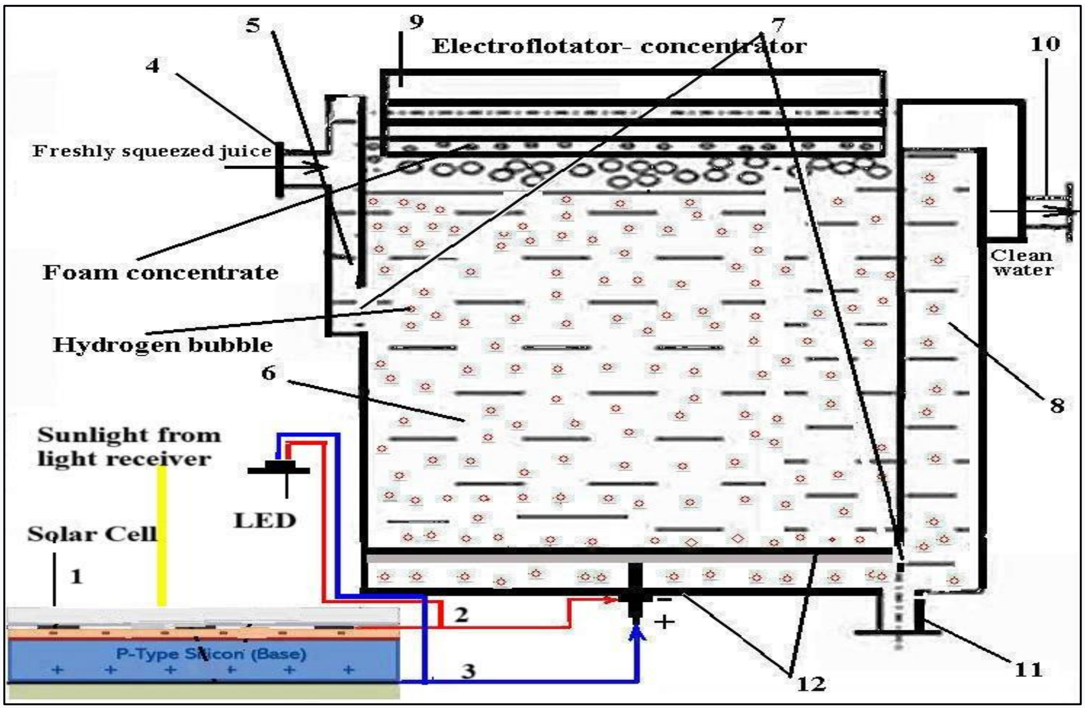

Figure 5. Design of the developed electroflotator concentrator continuous type, powered by a solar cell solar panel

The formed negatively charged microdispersed electrolytic hydrogen bubbles, floating to the free surface of freshly squeezed juice of the electroflotator, meet on the their way solid microparticles of sucrose, sugar and acid, the size of which is much larger than the size of microdispersed hydrogen bubbles, induce a positive charge on the surface of the microparticles and, due to the resulting force of electrostatic attraction opposite charges and surface tension forces, acting in one direction, are fixed on the surface of solid microparticles, forming strong foam from hydrogen bubbles and solid microparticles of sucrose, sugar and acid, the lifting volume of which increases sharply and, due to the increased force of Archimedes, the foam accelerates to the free surface of the freshly squeezed juice of the electroflotator.

Pop-up foam concentrate from hydrogen bubbles and solid microparticles of sucrose, sugar and acid is collected in the upper part of the flotation chamber and removed by a paddle device - 9 into a special receiving capsule.

The clean water, having passed through the post-treatment chamber - 8, is drained from the electroflotator-concentrator through a pocket and a drain pipe with a tap - 10.

After completing the washing of the electroflotator-concentrator and removing all remaining water, a pipe with a tap is provided - 11.

The round-the-clock supply of direct current voltage to the electrodes of a specially designed electroflotator is achieved by using sunlight from a light receiver transmitted via optical fiber as a backlight for the solar panel element, and a light-emitting diode (LED) with a battery charged during the day, by parallel connection with a working solar panel element, which begins to illuminate the solar panel element in the absence of sunlight in the room at night until the battery is completely discharged in the morning, and continuously filling the electroflotator with freshly squeezed juice.

4. Results and Discussions

At the Ganir plant (Israel), developed by authors, the round the clock concentration of freshly squeezed juice, using electrolysis of freshly squeezed juice in a specially designed electroflotator-concentrator, generated by direct electric current from a solar cell of solar panel was tested with authors participation.

The tests were carried out on a specially designed by authors the continuous-action electroflotator-concentrator (Figure 5), generating electrolysis of the aqueous component of freshly squeezed juice with a direct electric current, coming from the solar cell of the solar panel, causing intense formation of negatively charged microdispersed electrolytic hydrogen bubbles, flotation of solid microparticles of sucrose, sugar and acid,which allows obtaining a high-quality juice concentrate, as well as purified pure water.

The foam concentrate from hydrogen bubbles and solid microparticles of sucrose, sugar and acid is collected in the upper part of the flotation chamber of the electroflotator-concentrator and removed by a paddle device into a special capsule for receiving juice concentrate.

The concentration results are shown in Table 1 (I.R.D Laboratories). Results of the tests of the juice concentration, using electrolysis of freshly squeezed juice in a specially designed electroflotator-concentrator, generated by direct electric current from a solar cell of solar panel

Table 1. Results of the tests of the juice concentration

°Brix	Ratio	Ascorbic acid, Mg/L	Pulp, %
65,5	19,2	11.4	10

The total time of the process of juice concentration was 18 seconds. The Brix parameter in Table 1 is a measure of the mass ratio of sucrose, dissolved in water to liquid. The Ratio parameter in Table 1 is the ratio of sugar and acids in the obtained concentrate. Table 1 shows the results of obtaining a high quality juice concentrate.

The obtained concentrate is a highly concentrated with solid microparticles of sucrose and sugar a foam juice, which can be used to prepare a hydrogen cocktail with various additives of fruit juice from different fruits.

In order to determine changes in the parameters of the foamy juice concentrate, presented in Table 1, it was decided to determine the parameters of waste (purified) water, discharged from the flotation chamber of the electroflotator-concentrator after concentrating the juice, for the use of the developed electroflotator-concentrator in the process of treating wastewater, obtained after a general processat the plant.

Table 2 presents the results of wastewater treatment, obtained after the completion of the general technological process at the Ganir plant (I.R.D. laboratories).

Table 2. Results of the purification of waste water of the plant ganir

	°Brix	Pulp, %	COD, мг/л
Before cleaning	0.4	2.5	7100
After cleaning	0.1	0	80

The parameter COD (chemical oxygen demand) in Table 2 - determines the amount of organic pollutants of the water. Table 2 shows that parameter °Brix decreased from 0.4 to 0.1, and cellulose from 2.5% to 0.

The decrease of the values of these parameters is explained by the increase of their content in the juice concentrate after purification.

Attention should be paid to the COD parameter, which is the main indicator of water pollution by organic substances.

As follows from Table 2, after treatment, COD decreased from 7100 mg/l to 80 mg/l, which indicates the high efficiency of the developed method of juice concentration for wastewater treatment at this plant.

5. Conclusions

The developed by authors the round-the-clock concentration of freshly squeezed juice, uses electrolysis of the water component of freshly squeezed juice, generated by direct electric current from sunlight from a light receiver transmitted via optical fiber to a solar panel element, resulting in the formation of negatively charged microdispersed electrolytic bubbles of hydrogen and obtaining a high-quality concentrate of freshly squeezed juice by flotation of microsolid components of freshly squeezed juice with these bubbles.

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The conducted tests confirmed the production of high-quality fresh juice concentrate by means of the developed concentration in a specially developed electroflotator-concentrator.

The tests also showed that the developed concentration of fresh juice and the specially developed electroflotator-concentrator can be effectively used for wastewater treatment at this enterprise.

References

[1] V. D. Alves and I. M. Coelhoso, “Orange juice concentration by osmotic evaporation and membrane distillation: A comparative study,” *Journal of Food Engineering*, vol. 74, no. 1, pp. 125–133, May 2006, doi: 10.1016/j.jfoodeng.2005.02.019.

[2] K. Bélafi-Bakó, A. Boór, and N. Nemestóthy, “Comparative Study on Concentration of Juices from Colourful Wild Berry Fruits by Membrane Osmotic Distillation,” *Hungarian Journal of Industry and Chemistry*, vol. 40, no. 1, pp. 53–56, Sep. 2012, doi: 10.1515/318.

[3] S. Surin, P. Thakeow, P. Seesuriyachan, S. Angeli, and Y. Phimolsiripol, “Effect of extraction and concentration processes on properties of longan syrup,” *J Food Sci Technol*, vol. 51, no. 9, pp. 2062–2069, Sep. 2014, doi: 10.1007/s13197-013-1249-7.

[4] A. Elik, D. K. Yanık, M. Maskan, and F. Göğüş, “Influence of three different concentration techniques on evaporation rate, color and phenolics content of blueberry juice,” *Journal of Food Science and Technology*, vol. 53, no. 5, pp. 2389–2395, May 2016, doi: 10.1007/s13197-016-2213-0.

[5] J. M. Auleda, M. Raventós, J. Sánchez, and E. Hernández, “Estimation of the freezing point of concentrated fruit juices for application in freeze concentration,” *Journal of Food Engineering*, vol. 105, no. 2, pp. 289–294, Jul. 2011, doi: 10.1016/j.jfoodeng.2011.02.035.

[6] S. S. Deshpande, M. Cheryan, S. K. Sathe, D. K. Salunkhe, and B. S. Luh, “Freeze concentration of fruit juices,” *C R C Critical Reviews in Food Science and Nutrition*, vol. 20, no. 3, pp. 173–248, Jan. 1984, doi: 10.1080/10408398409527389.

[7] “‘Get healthy office lighting with natural light using products from “Parans. [Online]. Available: https://parans.com/product/

[8] D. Goff, *Fiber Optic Reference Guide*, 3rd ed. New York: Routledge, 2002. doi: 10.4324/9780080506319.

[9] J. Crisp and B. Elliott, *Introduction to Fiber Optics*, 3rd ed. Elsevier, 2005. doi: 10.1016/B978-0-7506-6756-2.X5000-5.

[10] E. Udd, “Fiber Optic Smart Structures,” in *Fiber Optic Sensors*, 1st ed., E. Udd and W. B. Spillman, Eds., Wiley, 2011, pp. 373–398. doi: 10.1002/9781118014103.ch14.

[11] C. M. DeCusatis and C. J. S. DeCusatis, *Fiber Optic Essentials*, 1st ed. Burlington: Elsevier Science, 2010.

[12] T. Okoshi, *Optical Fibers*, 1st ed. Elsevier, 2012.

[13] J. A. Buck, *Fundamentals of optical fibers*, 2. ed. in Wiley series in pure and applied optics. Hoboken, NJ: Wiley-Interscience, 2004.

[14] Y. Koike and M. Asai, “The future of plastic optical fiber,” *NPG Asia Mater*, vol. 1, no. 1, pp. 22–28, Oct. 2009, doi: 10.1038/asiamat.2009.2.

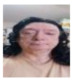
[15] J. A. Nelson, *The Physics Of Solar Cells*. World Scientific Publishing Company, 2003.

[16] A. Mohammad Bagher, “Types of Solar Cells and Application,” *American Journal of Optics and Photonics*, vol. 3, no. 5, pp. 94–113, 2015, doi: 10.11648/j.ajop.20150305.17.

[17] L. M. Fraas and L. D. Partain, *Solar Cells and Their Applications*. John Wiley & Sons, 2010.

[18] M. Shoikhedbrod, “Mechanism of Formation of Electrolysis Bubbles in Water and the Use of their Properties for the Development of New Technologies in Microgravity,” *Journal of Fluid Mechanics and Mechanical Design (e-ISSN: 2582-9165)*, vol. 3, no. 3, pp. 7–15, Sep. 2021.

Biographical notes



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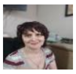

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