

Effect of Ultrasonic Wave Treatment in pH Value of Cabbage Juice

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ABSTRACT: This paper focuses on the effect of ultrasonic waves on the aqueous solution, here one of the important parameter called as pH have been considered and their effect experimentally is to be tested and evaluated. In this connection pH is essential parameter of any chemical solution further affect on chemical reaction and its yield product. In short, pH value controls reaction as well as product. Therefore taking in to consideration above fact control of pH for the chemical industrial product is found to be crucial one. A prototype laboratory scale experimental system has been designed to carry out the research work. On the basis of physical interaction of ultrasonic waves have been penetrating into the given solution and in the particular duration pH is recorded. Number of experiments carried out for different time duration.

This paper presents the result based on the observations and it also describes how pH can be controlled using ultrasonic waves. Finally paper concludes the comparison of results of change in pH between traditional methods and this innovative method of ultrasonic wave treatment.

KEYWORDS: Ultrasonic waves, pH solution, Cavitation.

I. INTRODUCTION

Although matter is divided into three groups, liquid is one of the major groups, which contain water called aqueous. This liquid or aqueous solution described by pH value which deals with OH^- ion and H^+ ion concentration. This is an important parameter in the field of chemical, metal formation industry in which chemical reaction based product yield. Further it is observed that pH is to be essentially needs to be controlled to get proper yield product. Therefore importance of pH and its control is a traditional practice of every chemical industry [3].

It is known that pH value of any solution lies in between 0 to 14 and it is divided into three groups namely: neutral solution (7), acidic solution (0 to 6) and basic solution (8 to 14). Experimentally it is found that in the process of chemical reaction to maintain the pH value is a crucial part to produce yield product [1]. Many more traditional practices are available for the said process solution. One of the benchmark systems of control the pH commonly used which is known as acid base flow control system [4]. This needs to control the flow of acid or base to maintain the pH value in the stirred tank. This system gives the better results practically but it requires lengthy amount of acid or base solution continuously flowing in the stirring tank and also require accurate flow control system to maintain accurate pH value [2].

It is found to be very difficult and critical one. Author of this paper also observed that this system is time consuming and not economic, environmentally hazardous. Therefore, we have introduced an innovative system of controlling the pH known as ultrasonic waves assisted pH controller. In this prescribed protocol instead of acid or base flow control the ultrasonic waves has been penetrated through solution for changing the ionic concentration (H^+ or OH^-) that is change in the pH value.

Ultrasonic wave generator is one time platform investment which replaces the frequent acid or base solution (environmentally hazardous) in the flow control which is the major advantage of this protocol. Therefore the next session presents its prototype design and modification to implement proposed protocol successfully.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 10, October 2016

Any matter can be affected number of parameters like temperature, pressure, stress, strain, etc. Study and observations indicates that the pH is most effective parameter on the aqueous solutions or chemicals. Most of the chemical reactions needs to be controlled the pH value. On the other hand, it may have disturbed the yield products [8].

This paper focuses on the effect of highly penetrating or treatment ultrasonic waves on pH. Ultrasonic waves responsible for decomposition of organic or inorganic solutions, which bear a pH value. It is found that ultrasonic energy transition deeply introduces and reacts with the OH⁻ or H⁺ ions concentration. Due to this transition, its pH value automatically changes for the given atmospheric surrounding.

This paper includes prototype experimental apparatus for getting accurate results and various analysis of pH value

Mathematically pH can be defined as

$$\text{pH} = -\log_{10} [\text{H}^+] = \log_{10} [1/\text{H}^+]$$

Water is a common solvent for all types of chemical reactions. Existence of acid and base is due to dissociation property of water. Aqueous solutions at 25°C with a pH less than seven are acidic, while those with a pH greater than seven are basic or alkaline. A pH level is of 7.0 at 25°C is defined as neutral because the concentration of H₃O⁺ equals the concentration of OH⁻ in pure water [7]. PH is important factor in each field of our life. Life is actually dependent on the pH of your blood. Human blood is slightly basic, with values ranging from 7.3 to 7.5. If the pH drops below 7.0 or rises up then body dies. In fact, all solutions including the foods that you eat, the fertilizer for your lawn, and the products that you use to clean your house, have a pH. They can be acidic, neutral or basic. Not knowing the pH of these solutions can cause harmful reactions [1].

Ultrasonic waves have very high frequency and very short wavelength [5]. Therefore, they can be focused in a narrow straight beam. Similarly, ultrasound is a cyclic sound pressure. Its frequency is greater than upper limit of human hearing. At present many techniques are used in food industry to preserve and increase the life of different fruits and vegetables, prior to subsequent processing. In food industry, blanching is one of the common methods that are used as a pre-treatment before drying, canning and freezing. Unfortunately, during the selected blanching type the whole system is often accompanied of functional properties as well as nutritional value of the product. However while buying the product customer is considering their visual perception of specific goods. However demand of fresh food with superior quality and nutritional properties was increased.

Paper is organized as follows. Section II was of related work, Section III describes material and methods and section IV describes about design and development in which we are using ultrasonic interferometer by which cavitation process occurs. Section V and Section VI describes about pH determination using pH meter and experimental arrangement also. Section VII and VIII explains experimental results showing results of images tested. Finally, Section IX presents conclusion.

II. RELATED WORK

In 1988, Bonnie Rose Curtin explained effect on paper pH and alkaline reserve from magnesium Bicarbonate Introduced via Ultrasonic Humidification. According to a Taylor Drop Test titration, the pH of the solution disturbed the pH of the liquid put into the tank. He selected two types of paper for the samples [13].

In 1989, Roger Gerf, Seyed-Taghi Salehi, and Daniel Rogez have developed ultrasonic Cole-Cole diagram for solutions and application to a-chymotrypsin. They were described in their paper that the simultaneous exploitation of velocity data as well as ultrasonic absorption. The greatest review of chemical effects of ultrasound is provided by Kenneth S. Suslick in 1989. He was the first chemist to show and recognized the unusual effects of intense sound waves travelling through a liquid that is known as sonochemistry. In spite of his early results, the study of sonochemistry remained modest. The amount of negative pressure depends on the type and the purity of the liquid. For pure liquids, the tensile strengths are very great that available ultrasound generators cannot produce sufficient amount of negative pressure to make the cavities [14].

Peter Pohl, Yuri N. Antonenko and Eike Rosenfeld have described on effect of ultrasound on the pH profiles in the unstirred layers near planar bilayer lipid membranes measured by microelectrodes, in 1993[12].

In 20th century work on effect of pH was developed so rapidly. Samuel Ko, etc.al was studied on the effect of pH on successive foam and sonic droplet fractionation of a bromelain invertase mixture in the year 2001[5].

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 10, October 2016

In 2005, Jinqiu Xua, et.al has described the ultrasonic decomposition of ammonia-nitrogen and organic compounds in coke plant wastewater. In his paper the investigations of the ultrasonic decomposition of $\text{NH}_3\text{-N}$ and organic compounds (i.e., CODCr) in coke plant wastewater are presented.

Very interesting work of ultrasonic effect on pH was done by Anet Jambra, Timothy J. Mas et.al. in 2007. They studied on ultrasound pre-treatment as a potential method prior to the subsequent processing in the food industry, for button mushrooms, Brussels sprouts, and cauliflower [11].

In 2010, Shengli Yang, et al. have described the ultrasonic effect on the mechanism of cholesterol oxidase production by *Brevibacterium* sp.

In 2014, Sandra Manso, Gemma Mestres, Maria Pau Ginebra, Nele De Belie, Ignacio Segura, Antonio Aguado have described on Development of a low pH cementitious material to enlarge Bioreceptivity. In which they explain it by a laboratory investigation into the development of a low-pH cementitious material in order to enlarge bio receptivity [9]. Here the entire experimental methodology based on principle of wave propagation of ultrasonic sound waves with respect to frequency. It is found that for a particular frequency range when we penetrate through a particular solution its pH will be change. This great dealing is further so useful in the industrial sector [6].

III. MATERIALS AND METHODS

For the evaluation of basic idea of effect of ultrasonic waves on pH can be studied by laboratory scale prototype ultrasonic pH controller. This method uses the physical material to build up an experimental set up and also uses basic laws of physics and chemistry. Therefore for getting the required results through proper experimentation following objectives have been considered.

- To study the effect of ultrasonic waves on pH of aqueous solution with reference to edible vegetables and fruit juices.
- To develop the prototype for experimental study control of pH for its application.

IV. DESIGN AND DEVELOPMENT

Ultrasonic wave or ultrasound is an oscillating sound pressure wave with a frequency greater than the upper limit of the human hearing range i.e. sound waves having frequency greater than 20 KHz are called ultrasonic waves.

Ultrasonic technology was invented using piezoelectric effect by Pierre curie around 1880. The ultrasonic waves create three distinct states within the fluid which are: Creation of cavity where extremely high temperatures and pressures are produced. Various observations have been taken and results are to be recorded and compared.

V. pH DETERMINATION AND STATISTICAL ANALYSIS

pH of the solution before and after ultrasound were determined by pH meter. The measurements were carried out by placing pH electrode in the cabbage solution.

When ultrasonic waves were passed in a cabbage juice, pH was measured after time interval of one hour. The effect of the ultrasound treatment on the properties investigated and determined pH values for different periods were noted.

VI. INSTRUMENTATION

Instrumentation includes glass material reactor fitted with ultrasonic generator and pH measurement system which is as shown in figure. Doubly coated glass reactor consists of water cooling arrangement to maintain the temperature. Chemically well filtered juice of cabbage is taken to carry out the experiment as shown in fig. (1)

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 10, October 2016

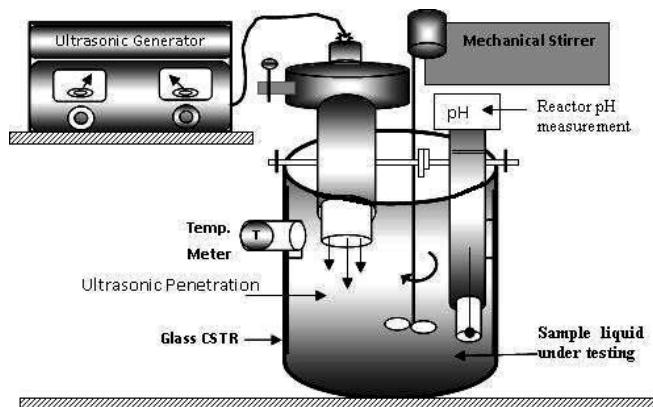


Fig. 1 Prototype laboratory Equipment for penetration of ultrasonic waves in the electrolyte solution

VII. EXPERIMENTAL PROCEDURE

Ultrasonic sound is penetrated through the cabbage juice (volume one litre) with the fixed frequency at constant temperature. Initially, on the ultrasonic generator pH value is measured using digital pH meter. For each hour readings are recorded from the time of penetration of ultrasonic waves. Other physical and chemical parameter of juice is also recorded for further analysis with reference to effect on pH simultaneously. Experiment is repeated for various juice concentrations, volume and observations are recorded for further analysis. Thus laboratory scale prototype system for measurement of effect of pH with respect to time and other physical parameter of the juice and the reactor provided constant environmental conditions.

- Cabbage juice is taken as a sample which is naturally quite acidic in nature of pH = 5.51.
- The ultrasonic wave generator is used to penetrate the waves in the cabbage juice and change in pH is observed (pH 5.96 within 2 hrs.)
- The experiment is carried out and pH is measured for every 1 hour successively which is tabulated in the observation table.

VIII. OBSERVATION TABLE

The experiment is carried out for cabbage juice and after each 1 hour pH is measured successively. The value of pH is measured before penetration of ultrasonic waves and then after penetration of ultrasonic waves for each 1 hour. Observations are shown in the observation table given below:

Sr. No.	Time interval (hrs)	pH before penetration of ultrasonic waves	pH measured after penetration of ultrasonic waves
1	0	5.51	-
2	1		5.61
3	2		5.69
4	3		5.76
5	4		5.96

Table 1 Value of pH before and after penetration

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Issue 10, October 2016

IX. RESULTS AND DISCUSSION

The ultrasonic waves penetrated through the cabbage juice with the fixed frequency at constant temperature. For each hour readings are recorded from the time of penetration of ultrasonic waves as described in the observation table. Penetration of ultrasonic waves alters pH value of cabbage juice from 5.51 to 5.96 (tending towards neutral; pH = 7) within 2 hrs. In the present study, the parameter i.e. pH changes are observed before penetration of ultrasonic wave and after penetration. This research work basically compares traditional control with the ultrasonic control of pH, the comparison motives for further research work for greater industrial application. Penetration energy of ultrasonic gives the measure change in the pH value.

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