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Experimental Study of the Interaction of Magnetic Fields with Flowing Water

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Abstract – *The interaction between magnetic energy and flowing water molecules has been experimentally investigated via measuring a number of physical parameters including absorbance, refractive index, thermal conductivity, viscosity and surface tension. A stack of 16 permanent magnets was also used and arranged to attain a nearly homogeneous magnetic field of 6500G over the region through which the water was allowed to flow. All experiments were performed at ambient room temperature when the water was allowed to pass the region of the magnetic field within typically 2 minutes. Measurements of the absorbance were obtained over wavelengths ranged from the UV to near IR light where the spectra were compared with those of the same type of water before applying the magnetic field. Water samples were taken from different sources, to have various compositions with the use of the same containing cell to ensure the same path length of incident light throughout all measurements. Experiments were found that the absence was increased after exposing to a magnetic field in both UV and NIR regions by a factor of 23% and 6%, respectively. Other physical properties of magnetized water were also inspected with proper and precise measuring techniques. These include the pH which was increased by 12%, TDS and EC are both decreased by 33% and 36% consequently. As well as the mechanical parameters like viscosity and surface tension are decreased too by a factor of 23% and 18%, respectively. Even, the thermal conductivity was decreased by 16%. So, it was found that some properties of water were changed a lot of new and strange phenomena were discovered after magnetization.*

Key Words – *Magnetized water, water magnetization***.**

1 Introduction

The interaction of magnetic energy with water has stimulated a spreading research interests which may be essential for widening the use of magnetized water in various areas as well as understanding the fundamental physics of such interaction. The importance of magnetized water has been arisen from its versatile use in industry [1], Agriculture [2], irrigation [3], medicine [4], and possibly in low-power pulsed plasma discharges which require gas-water interfaces.

So far, the effect of magnetic field on water has been recognized as nonlinear problem and proposed the mechanism of magnetization of water according to the structure and distribution of its molecules [5].

After magnetization, the polarization features of molecules and their distribution in magnetized water are altered. Such changes of water molecules result in the variations of the transition character of the electrons in these molecules. Accordingly, it was found that the absorbance of magnetized water is increased over the UV-NIR regions [6] under magnetic fields of up to 4400G.

Other research experiments have been concerned with the study of absorbance [7], pH, total dissolved solids (TDS) [7-8], electrical conductivity (EC) [9], refractive index, coefficient of finesse [10-11], viscosity, surface tension [12] and thermal conductivity.

Although most experiments have dealt with moderate ranges of magnetic field strengths, experiments were carried out to study the effect of strong magnetic field of 14T on both water and glucose over a wavelength ranging between 900nm and 2000nm. These experiments have shown that the peak of wavelength increased in length by 1-3nm in water and a blue shift in the glucose solution when path length was changed from 0.1mm to 100mm [13]. This type of experiments may provide evidence on how the formation of the hydrogen-bond of water molecules is influenced by a strong magnetic field.

In the present paper, experimental investigations of absorbance, pH, (TDS), EC, viscosity, surface tension and thermal conductivity were carried out for ordinary tap water before and after applying magnetic fields of strength 6560G which were generated by proper arrangement of permanent magnet pieces around the pipe accommodating the flowing water.

2 Experimental setup

The experimental setup consisted mainly of a PVC pipe of length 50cm, inner diameter 1.25cm and outer diameter 2.17cm. This pipe joins two plastic reservoirs of a nominal volume of 20L each. One reservoir was used as a tap water container, i.e., for pure water before magnetization and the other was to collect water after being magnetized.

A flowmeter, type (LZM-25Z), was used for monitoring the flow rate of water and two control valves were also fitted into the PVC pipe as experimentally required. The magnetic field was generated by symmetrically arranging 16 pieces of permanent magnet around the PVC pipe. These magnets have been supplied by GMX Co. and the dimensions of each piece were (6cm, 2cm, and 2cm).

The overall distance over which the magnets were arranged was 28cm which can be considered as the region of direct exposure of water to the magnetic field generated by these magnets. However, magnetic field of less value could also exist on both sides of the direct magnetization region. A schematic diagram of the experimental setup is illustrated in figure (1).

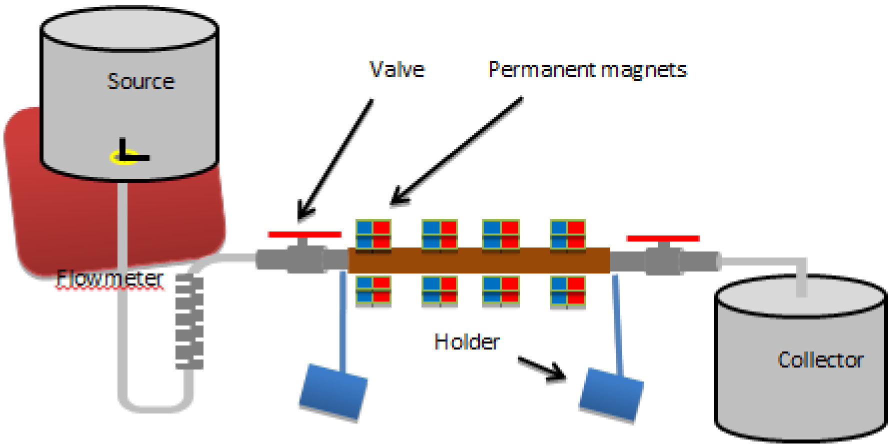

Fig. 1: A schematic of the experimental setup

When water flows out from the magnetization region of the setup to the collecting reservoir, a glass pipette of 10ml in volume was immediately used to transfer samples of magnetized and non-magnetized water into a number of test tubes; the volume of each one is 10ml. By doing so, the spectroscopic measurements required a 5mL of collected water, while other measurements needed a 500mL. These samples were taken from the collecting reservoir and/or from the test tubes. It's worth mentioning that these test tubes and the flasks were thoroughly cleaned and dried before each test.

The absorbance measurements of water samples were carried out using a computerized spectrometer, model SP-8001 supplied by Shimadzu, over the UV and NIR regions, i.e., typically from 190nm to 240nm and from 900nm to 1050nm.Three more parameters have been studied in the present article which are TDS, EC and pH. The TDS and EC have been measured by a pH/EC/TDS meter, model HI9812. This instrument was capable of measuring the pH (dimensionless), EC in (µS/cm) and TDS in (ppm or mg/L). The amount of TDS of both magnetized and non-magnetized water was measured by having 500ml of the water in a flask with a probe dipped inside the water. Three readings for the same sample were recorded and the final value of the TDS was their average. From another channel in the instrument the EC was recorded since there is a relationship between the amount of TDS and EC since more TDS brings about higher EC. Moreover, the pH values of the water samples were measured by a digital pH meter of model professional Benchtop pH BP3001. The pH measuring procedure is similar to that followed in above measured of TDS and a time required for having the probe in the water is 40s for getting the final reading.

Two parameters categorized as mechanical properties; viscosity and surface tension have been investigated and measured for magnetized and non-magnetized water. For cross-checking, a method was adopted which involved the use of a digital surface tension meter of model SEO-DST30, where the reading displayed by the device represents a direct measurement of surface tension in units of (dynes/cm). While the measurements of viscosity, a method was adopted which involved the use of a digital viscometer of model ST-2020L, where the readings that displayed by the device are the direct measurements of viscosity in units of (mPa.s).

The thermal conductivity of water was measured by using a digital device of type KD2 Pro. When The KD2 Pro probe was dipped into a 10mL-glass graduated cylinder of water for 90s which is the time required for recording the final reading. The reading displayed by the device represents the direct measurement of thermal conductivity in the units of (W/K m).

3 Results and discussion

Since the present article is concerned with some characteristic properties of magnetized water, this section is devoted to present results of the effect of magnetic field on a number of physical parameters which include absorbance, pH, TDS, EC, viscosity, surface tension and thermal conductivity.

3.1 Absorbance

In the present analysis, absorbance is defined as the fraction of radiation absorbed by water samples at specific wavelengths. For both magnetized and non-magnetized water, figure (2) displays the absorbance in the wavelength range 190nm-240nm. The strength of the applied magnetic field was 6560G at room temperature. Results have depicted an increase in the absorbance at a wavelength of 191nm by a factor of 23%. In the wavelength range 900nm-1050nm, the absorbance experienced an upgrade of 6% at a particular wavelength of 976nm when water was influenced by the same magnetic field strength as demonstrated in figure (3).

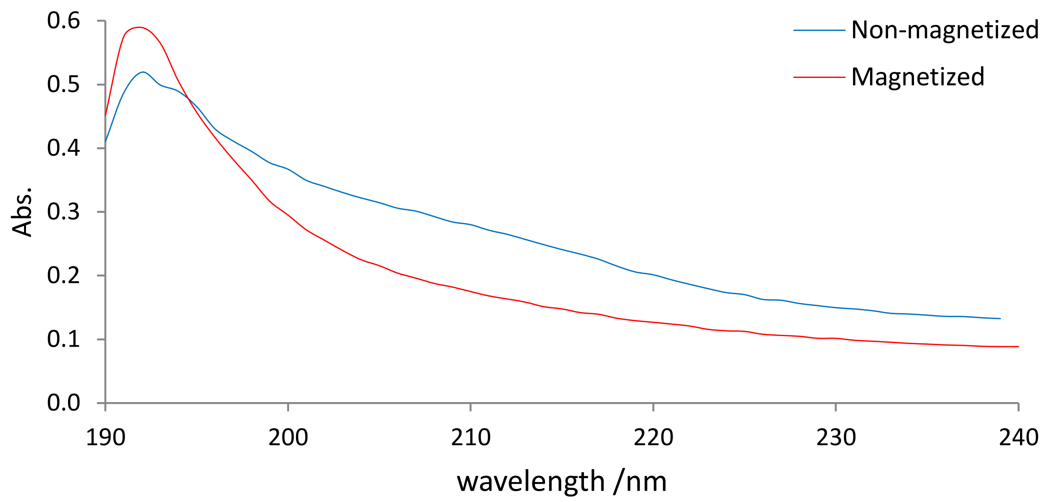

Fig. 2: Absorbance of magnetized and non-magnetized water UV region

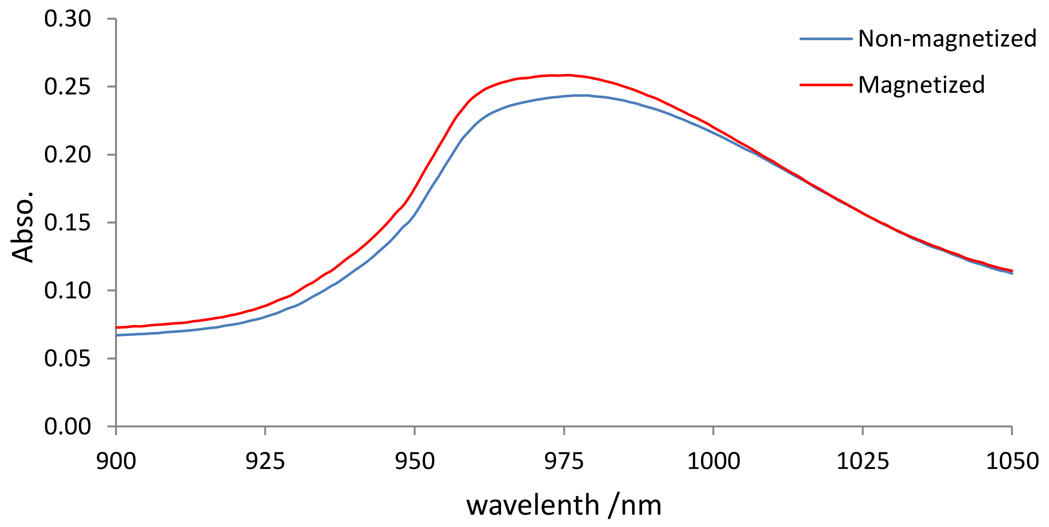

Fig. 3: Absorbance of magnetized and non-magnetized water in NIR region

Since the water contains a lot of molecular structures which can be magnetized by the application of an external magnetic field, these small structural elements become small magnets. This indicates that water is magnetized under these conditions, but its molecular constitution does not change.

However, after magnetization the polarized properties and transition of the dipole moments of molecules are only enhanced revealing to those of non-magnetized water [14].

In addition, a current may be generated within the bulk of magnetized water by the movement of electric charges forming the dipoles. Moreover, these results may provide that electronic and vibrational transitions exist when the water samples are subject to a magnetic field.

3.2 pH

The pH value of water is a measure of its acidity or alkalinity, therefore its level indicate the activity of hydrogen [15]. When water exposed to a magnetic field, results have shown an increase in the pH by a factor of 12% of the application of magnetic field of strength 6560G. As illustrated in figure (4).

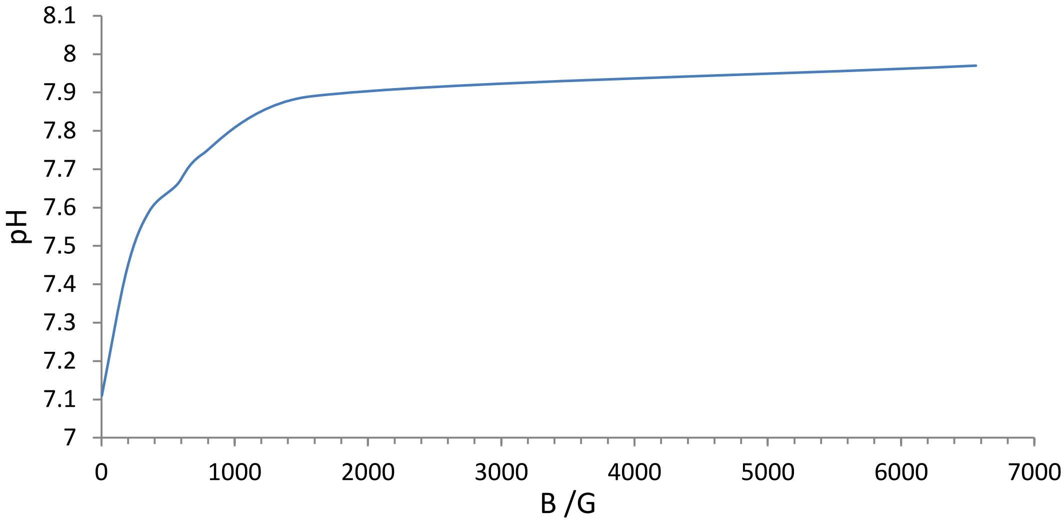

Fig. 4: pH variation of Magnetized water

It's essential to bear in mind that ordinary tap water has a pH value of around 7. Upon applying a magnetic field, many hydroxide (OH^-) ions are formed calcium bicarbonate and other alkaline material, this helps to raise the pH value, which reduces acidity [16].

3.3 TDS and EC

Experimental results of water have shown that TDSs were decreased after the water had been exposed to a magnetic field. Since EC is related to the parameter TDS, therefore, after applying a magnetic field Both EC and TDS were reduced as shown in figure (5). The percentage increase in TDS and EC amounted to 33% and 36%, respectively. As a result of applying a magnetic field of strength 6560G.

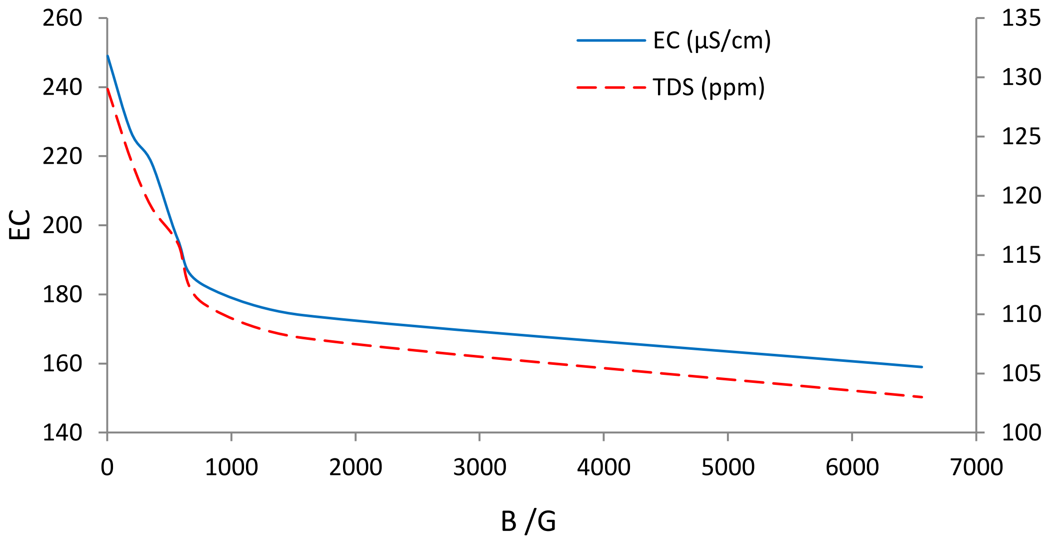

Fig. 5: Variation of TDS and EC of Magnetized water

3.4 Viscosity (η) and surface tension (ɣ)

The toe parameters viscosity and surface tension of magnetized water well also covered in the present Experiments. Results have illustrated that these tow parameters were degraded when non-magnetized water had become magnetized by exposing it to a magnetic field of strength 6560G, figure (6).

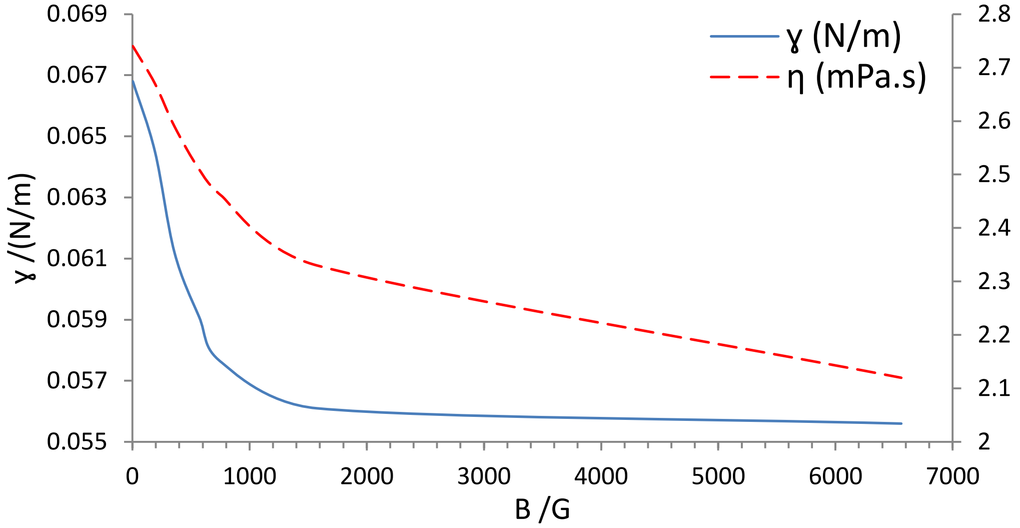

Fig. 6: The variation of viscosity and surface tension of Magnetized water

The amount of reduction in viscosity and surface tension were recorded as 23%, 18%, respectively.

Such observations may be justified in terms of the influence of magnetic field on the hydrophobicity of water. The surface tension is decreased relative to that of non-magnetized water by extenuation of contact angle between water drops and surface [6].

Moreover, the magnetic field may result in variations of the distribution and clustering structure of molecules, which can cause necessary changes of macroscopic properties of water including the surface tension [19].

3.5 Thermal conductivity (Ƙ)

In heat transfer, the thermal conductivity of a substance, k, is an intensive property that indicates its ability to conduct heat [18]. After being exposed to a magnetic field, the thermal conductivity of water has been found to decrease as demonstrated in figure (7). An amount of 16% reduction in the thermal conductivity was obtained with the same magnetic field value mentioned above which is 6560G.

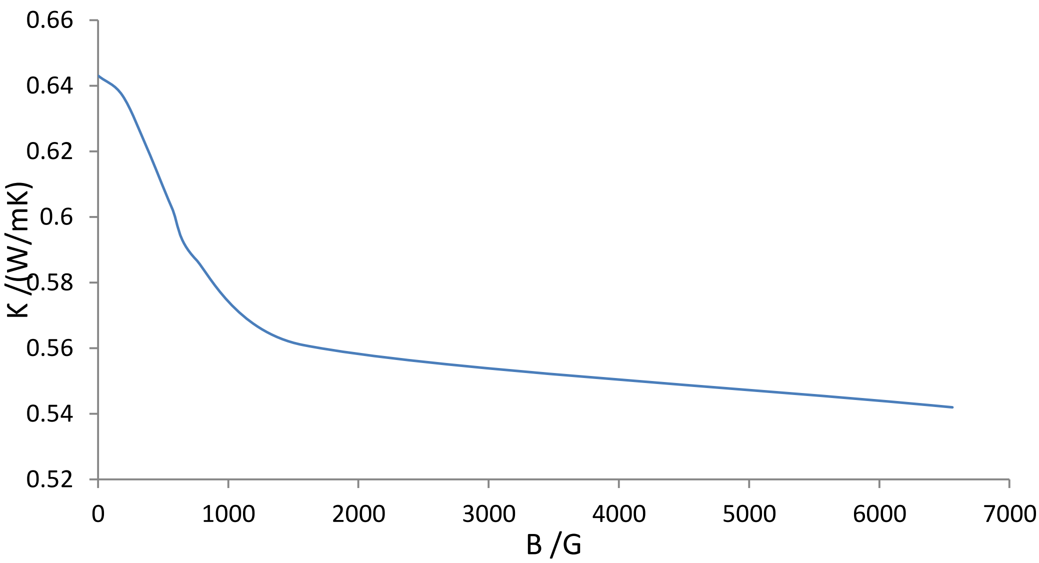

Fig. 7: decrease of thermal conductivity of Magnetized water

4 Conclusion

Experiments involving the effect of an externally-applied magnetic field of strength 6560G have shown demonstrated certain level of variations in typical physical quantities such as absorbance, pH, TDS, EC, viscosity, surface tension and thermal conductivity.

- When water is exposed to a magnetic field, the absorbance was found to increase at the same wavelength position by 23% and 6% in UV and NIR regions, respectively.
- When water is magnetized, chemical parameters such as TDS and EC experienced degradation of 33% and 36%, respectively. On the other hand, the pH parameter showed an upgrade of 12%.
- After being magnetized, the viscosity of water is reduced by 23%, meanwhile, the surface tension is lowered by 18%.
- When water samples are exposed to a magnetic field of 6560G, the thermal conductivity is decreased by 16%.

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