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Effect of Degassing on the Electrical Conductivity of Pure Water and Potassium Chloride Solutions

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Recently, a significantly higher value was reported for the conductivity of pure water, in the absence of dissolved gases. These initial observations have been repeated in this study but with an improved experimental system, giving more accurate results than those reported in the initial experiments. Also reported here are measurements of the conductivity of pure water as a function of temperature and the extent of dissolved gas removal. In addition to the pure water studies, the effect of dissolved gas on the conductivity of dilute potassium chloride salt solutions was also examined.

Introduction

A report in 2005 first addressed the influence of dissolved, nonpolar atmospheric gases and the removal of these gases on the electrical conductivity of pure water, in the absence of dissolved carbon dioxide.[1] The concentrations of these solutes (oxygen and nitrogen gas), present at a level of one gas molecule per fifty thousand water molecules, for water equilibrated with the atmosphere, are so low that most properties are expected to be unaffected by the removal of these gases. These gases have usually been considered as inert. However, some physical properties, such as the electrical conductivity of water, are extremely sensitive to solutes, especially ions. The natural conductance of ‘pure’ water is based on the transport of protons and hydroxyl ions chiefly by water molecule linkages and sequential bond cleavage.[2] It has been shown recently that water molecules have two strong bonds in bulk water, which indicates that the molecules will tend to form molecular networks of hydrogen-bonded rings and linear chains.[3] Nonpolar solutes might be expected to form clathrate-like rings, which will reduce or disrupt the chains used to conduct the electrical current in pure water.[4] Hence, it is possible that even the presence of millimolar concentrations of these disrupting solutes might reduce the conductivity of water and that complete removal of these solutes might significantly increase the conductivity of water.

In the classic work of Kohlrausch and Heydweiller in 1894,[5] which contains the commonly accepted literature value for the conductivity of pure water, the electrical conductivity was measured for clean, vacuum-distilled water, distilled under only a partial vacuum to facilitate distillation and not to remove dissolved oxygen and nitrogen. The degassed results obtained in 2005[1] are summarized in Table 1. These results were obtained by removal of dissolved, atmospheric gases using the freeze−thaw−pump technique and subsequent measurements were carried out under a flow of pure nitrogen gas. The difficulty in carrying out these experiments could explain the wide distribution of the results reported, i.e., 1.2 ± 0.5 μS/cm. In the work reported here, the experimental design was aimed at reducing these errors so that more accurate values could be obtained. This was achieved with a specially designed, vacuum conductivity cell.

TABLE 1: Summary of Electrical Conductivity of Pure Water under Various Conditions

	conductivity (μS/cm)	pH	temperature (°C)
equilibrated with air	0.9	5.7	25
nitrogen purged	0.07	7.0	25
degassed	1.2	7.0	25
literature value[5]	0.055	7.0	25

The role these nonpolar solutes play in water structure can be better understood from accurate data on the electrical conductivity of water in the absence of dissolved gases. A paper published in 1995 discusses the change of water structure when hydrophobic groups are dissolved in to the bulk solution.[3] These hydrophobic groups distort the water structure around them, forming clathrate structures which alter the physical properties of the solution. As dissolved gases are essentially hydrophobic groups, the same reasoning would follow that ordinary nitrogen gas purged water would contain these clathrate groups, which would distort the structure. By comparison, completely degassed water would be undistorted and so should give a far more accurate model of pure water.

In 1969, Baker et al. calculated the energy, specific heat and radial distribution of liquid water via computer simulation,[6] yet in doing so they constructed a model ignoring the gas molecules present. Theoretically modeling water is a computationally intensive procedure, for example it was recently noted that computationally modeling a protein molecule in water required 99.65% of the computational power just to model the water interactions.[7] Even when hydrophobic solutes are taken into account there is a large amount of conjecture on the degree of order of the shells assumed to form around these molecules.[7] Water modelers are now opting for simpler models and calculating the efficacy of these models from first principles and ignoring experimentally derived values, as the most complex models could not predict the natural properties of water accurately enough.[8] The work presented here suggests that calculations of the natural conductivity of water should be directly compared with the experimental values obtained on completely degassed water samples. These comparisons should reflect the true behavior of liquid water molecules more closely.

The accepted literature value of ‘pure’ water’s conductivity is around 0.055 μS/cm at 25 °C.[5] However, the study reported in 2005 found that the electrical conductivity value obtained

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for ‘pure’ water can easily be achieved by nitrogen gas purging single-distilled water for an hour.[1] This value agrees with the value found by Kohlrausch and Heydweiller in 1894,[4] and so has often been repeated and gone unchallenged. In the present study, other gases were also studied and their effect on the electrical conductivity of water monitored over time. The gases studied were argon, oxygen, methane and helium. Oxygen, methane and argon are all more soluble than nitrogen and so it would be expected that the addition of these gases would lower the conductivity further than for nitrogen. Helium is one of the least soluble gases and as such it would be expected that the addition of helium would have little effect on the conductivity of water.

The theoretical conductivity of pure water is often calculated from the equilibrium 10^{-7} M concentration (at 25 °C) and the conductivities at infinite dilution of H_3O^+ and OH^- ions. The ion conductivities of the corresponding electrolyte solutions (NaCl, NaOH, and HCl) presumably have also usually been measured under CO_2-free nitrogen gas (i.e., rather than in completely degassed solutions). Extrapolation to infinite dilution for the hydroxyl ion and hydronium ion in water of Λ_{OH}(infinite dilution) = 199.2 S cm^2 mol^{-1} and Λ_H(infinite dilution) = 350.1 S cm^2 mol^{-1}, gives $\Lambda(\text{total}) = (199.2 + 350.1) \times 10^{-10}$ S cm^{-1} = 0.055 μS cm^{-1} at 25 °C. This value is the same as that accepted as “standard” (for example, the SI data Book) and agrees closely with the best measured value of Kohlrausch and Heydweiller of 0.058 μS cm^{-1}.

If ionic solutions are affected by the removal of dissolved gas in a similar manner to pure water, then these values must have been underestimated. These infinite dilution molar conductivities are determined by measuring the molar conductivities of incrementally reducing concentrations of hydroxyl and hydronium solutions. These values are then graphed against the square root of the concentration in a Kohlrausch plot, so-called as the relationship between molar conductivities and the square root of concentration is derived from Kohlrausch’s law:

$$\Lambda_m = \Lambda_m{}^o - A\sqrt{C} \tag{1}$$

where Λ_m is the molar conductivity at a particular concentration C, A is a constant which can be experimentally determined and $\Lambda_m{}^o$ is the molar conductivity at infinite dilution.

The $C = 0$ intercept of the plot generated corresponds to the infinite dilution of the ionic system from which the individual molar conductivities of the ions can be calculated. The effect of dissolved gases on the electrical conductivity of dilute ionic solutions is reported here.

Experimental Methods

Distilled water was produced from tap water via a sequential process of coarse filtration, activated charcoal filtration, reverse osmosis filtration, and finally, distillation into a Pyrex glass storage vessel housed in a laminar-flow, clean-air cabinet. All the chemicals used were of the purest grade commercially available. The potassium chloride used was Analar grade and was baked in and oven at 120 °C to ensure it was completely dry. The nitrogen used to purge the water prior and post degassing was ultra high purity (UHP) nitrogen from BOC Gases. The methane gas used in the experiments was grade 4.0 ultra high purity sourced from Airgas in America. The helium gas used in the conductivity suppression experiments was 98% pure with a slight impurity of water. The conductivity probe used was a Mettler Toledo 7001/120 VP 3.1B probe. The probe consisted of two electrodes, a Pt1000 electrode for temperature measurements and an SS 316 L electrode for conductivity measurements. The body of the probe was also manufactured from stainless steel and insulated with polyetherether ketone (PEEK). Viton (a fluoroelastomer available from DuPont) O-rings were used to seal the probe. The probe was connected to a Cond 7100e module and was sealed into a Pyrex tube with a PTFE sleeve, as shown in Figure 1. The tube was sealed with a PTFE O-ring abutting the probe’s sleeve and the flask had a Teflon tap attached to allow dissolved gases to be evacuated. The pear shaped flask housing the probe was washed with ethanol repeatedly and then flushed with copious amounts of ultra pure water prior to each experiment. 150 mL of water or potassium chloride solution was introduced into the 250 mL vessel and the carbon dioxide was removed by bubbling ultra pure nitrogen through the solution for 15–20 min to raise the pH to 7. The conductivity was then measured by inverting the tube and was found to either be below 0.1 μS/cm for the pure water samples or in the case of the potassium chloride solutions measured against reference values to ensure the accuracy of the prepared solution. The dissolved gas was removed from the solutions by a process of repeated freezing in liquid nitrogen, followed by pumping down to a pressure of 0.01 mbar and then melting in a sealed tube. The dissolved gas produced on each melting cycle was removed on refreezing. Although this process was carried out nine times due to the increased volume and conformation of the vessel, typically no further degassing on melting was observed after 7−8 cycles. The vacuum pressure of 0.01 mbar corresponds to a degassing level of about 99.999%, if it is assumed that the final pressure achieved on several cycles of freeze/thaw/pumping is given by the pressure in equilibrium with the final frozen liquid, which on being melted does not give any visible bubbling/outgassing. After the degassing process

Figure 1. Conductivity vessel: Mettler Toledo 7001/120 VP 3.1 B probe sealed in pear shape flask via PTFE sleeve.

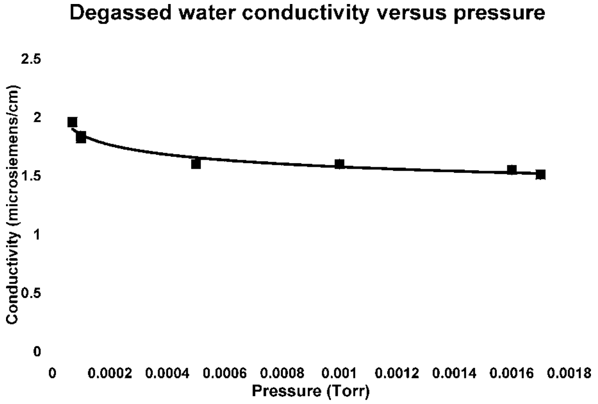

Figure 2. Electrical conductivity of water against pressure.

the vessel was immersed in a Julabo F10 thermostatically controlled water bath and the temperature equilibrated at 25 °C prior to measurement. After the electrical conductivity of the solution was recorded the solution was opened to atmosphere and again purged with ultra pure nitrogen to yield a control nitrogen value to which the degassed could be compared and the exact concentration could be calculated. The conductivity suppression experiments involved measuring the conductivity of atmospheric equilibrated pure water and then purging the solution with the selected gas over an hour in the pear shape conductivity flask. The conductivity was monitored over ten minute increments and was usually found to reach a minimum in 20−30 min.

Results

The dramatic increase in electrical conductivity upon degassing found in the original study was reproduced in this study. However, it was also discovered that the conductivity values were dependent on two important factors, the temperature the degassed sample was measured at and the extent of degassing. Typical samples were heated to 25 °C after degassing and thermally equilibrated before they were measured. The results obtained indicate that the most important factor to affect the conductivity values was the degree to which the sample was degassed. These results indicate that the higher the removal of dissolved gas, the higher the electrical conductivity of the resulting solution. Figure 2 presents the results obtained at different levels of degassing. It is, of course, impossible to achieve absolute degassing and the vacuum pressures achieved here were only modest. However, the results obtained in Figure 2 clearly suggest that the total removal of dissolved gases will produce an even larger effect than previously reported.

The electrical conductivity was also found to be dependent on the temperature, with the conductivity rising with increasing temperature. The resulting trend shows a fairly steady increase in electrical conductivity with temperature, with a slight tapering off around 60 °C, observed in some samples (Figure 3). For comparison, Figure 4 presents the trends between the electrical conductivity of nitrogen purged water and the electrical conductivity of degassed water, with increasing temperature.

Following a better understanding of the important role of pressure and temperature on the electrical conductivity of degassed water, several samples were degassed to the highest degree possible with the apparatus used in this study ($<1 \times 10^{-4}$ Torr). The resulting solutions were thermally equilibrated to 25 °C in a water bath. These values gave a tighter range than that seen in the previous study. The electrical conductivity of pure water at 25 °C, obtained at the lowest pressure of 7×10^{-5} Torr, corresponding to >99.9999% of dissolved gas removed, was found to be: 1.90 ± 0.10 μS/cm.

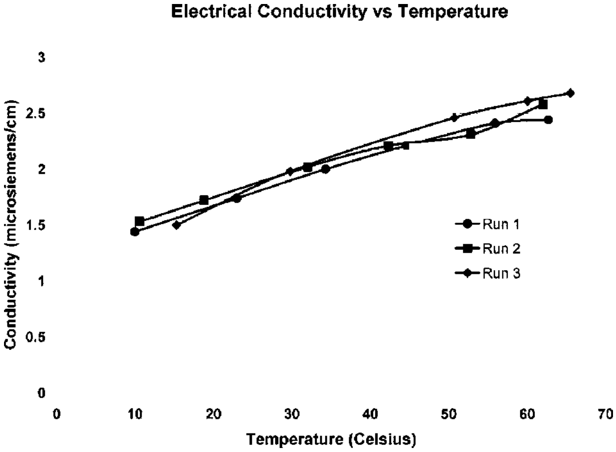

Figure 3. Electrical conductivity of degassed water against temperature.

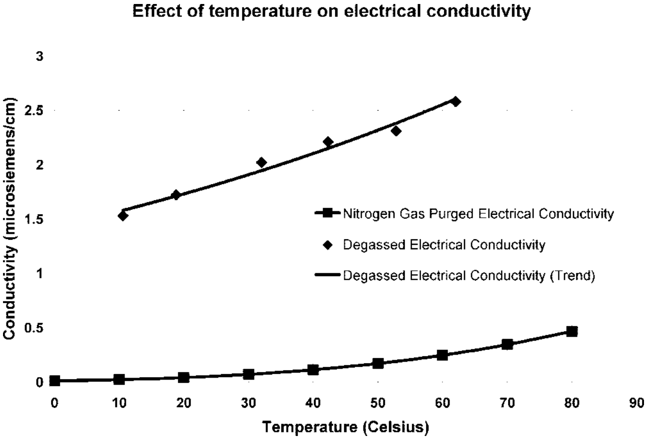

Figure 4. Comparison of degassed and nitrogen purged water electrical conductivity versus temperature. Nitrogen purged values taken from Light et al.[9]

To ensure that the increase in conductivity found through the removal of the dissolved gases was not due to ionic contamination, the solutions were purged with pure nitrogen gas, after the measurement was recorded, and the conductivity monitored. Figure 5 shows the results obtained for the electrical conductivity of degassed and atmospheric water samples, as they are purged with nitrogen gas, over an hour. As can be seen from this figure, purging both solutions with nitrogen gas dropped the electrical conductivity, for both samples, to around 0.1 μS/cm after an hour. The successful suppression of the conductivity of degassed and atmospheric water, rules out the possibility of any ionic contamination as the cause of the high values for degassed water.

The effect of a series of other purging gases, helium, argon, oxygen and methane gas were studied by bubbling through atmospheric water for an hour and the conductivities monitored. Table 2 presents the electrical conductivity values for water samples after each of the four gases was bubbled through the solution.

The role of dissolved gases on the conductivity of dilute, aqueous potassium chloride salt solutions was also examined. Solutions of potassium chloride at concentrations of 1×10^{-6}, 1×10^{-5}, 1×10^{-4}, 1×10^{-3}, 5×10^{-3} and 1×10^{-2} M, were measured. At low salt concentrations the presence of dissolved gas was found to have a significant effect on the

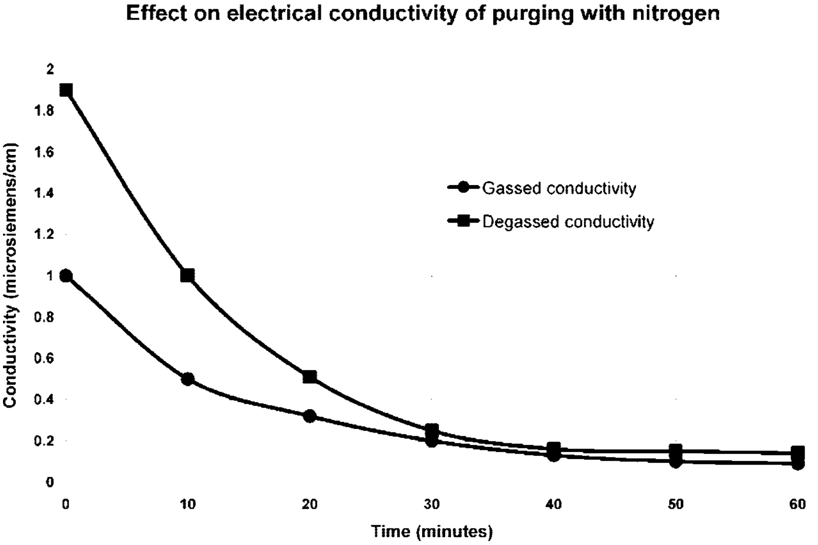

Figure 5. Effect of nitrogen purging on the electrical conductivity of samples of atmospheric and degassed water.

TABLE 2: Conductivities, Solubilities and Polarisability Volumes of Various Gases When Added to Water

gas	solubility (g/kg at 20 °C and 1 atm)[4]	polarizability volume (10^{-30} m^3)[10]	maximum suppression conductivity (μS/cm)	average suppression conductivity (μS/cm)
nitrogen	0.0190	1.74	0.07	0.09
argon	0.0590	1.64	0.15	0.3
helium	0.0015	0.20	0.38	0.4
methane	0.0232	2.59	0.08	0.08
oxygen	0.0434	1.58	0.18	0.21

conductivity, while at high salt concentrations this effect was much less marked. The results shown in Figure 6 indicate that degassed and nitrogen purged potassium chloride solutions share the same overall trend, which is not surprising, as ionic effects would be expected to dominate.

Figure 7 shows the difference between the degassed and nitrogen purged KCl solution electrical conductivities for dilute solutions and Table 3 presents the average recorded values of the electrical conductivities of degassed and nitrogen purged samples of potassium chloride solutions at different concentrations.

A constant difference between degassed and nitrogen purged salt solution values, of about 1 μS/cm, was observed for all potassium chloride solutions, after the removal of the dissolved gas. The degassed samples were purged with nitrogen gas after measurement to provide a conductivity from which the exact concentration could be determined using Kohlrausch's law. This was done because the conductivity of the final gas samples was higher than the initial gas samples, as some water was lost during the freeze thaw procedure. Note that at the dilute KCl concentrations of 1×10^{-5} and 1×10^{-6} M, the samples varied in electrical conductivity, upon purging with nitrogen, most likely due to background, contamination electrolyte effects and as such were not used in the construction of the Kohlrausch plot. A Kohlrausch plot was constructed from the gassed and degassed 1×10^{-3}, 5×10^{-3} and 1×10^{-2} M concentrations of KCl and this plot is shown in Figure 8.

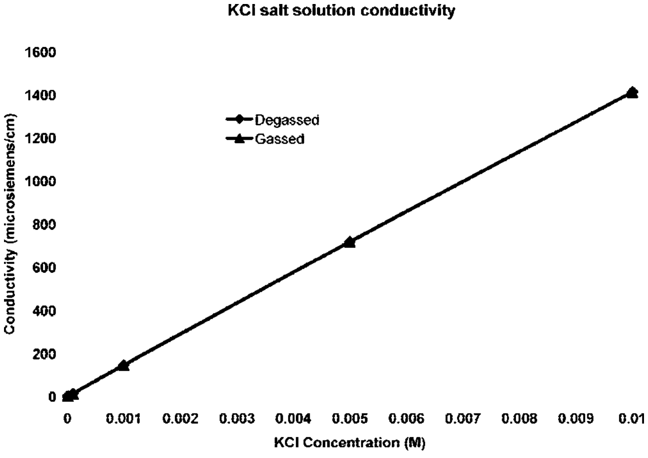

Figure 6. Overall trend of electrical conductivity of KCl solutions are varying concentration.

The literature molar conductivity at infinite dilution for KCl is 149.86 S cm^2 mol^{-1},[13] whereas for the nitrogen purged system this value was found to be 149.5 S cm^2 mol^{-1}, while for the degassed salt solutions the molar conductivity at infinite dilution was found to be 151.4 S cm^2 mol^{-1}.

These results indicate that although ionic effects do dominate the overall electrical conductivity, the removal of dissolved gases still has a significant effect on this property.

Discussion

It has been confirmed in this study that the removal of dissolved gases from pure water raises its electrical conductivity well above the literature and atmospheric values previously reported. The possibility of an artifact however, must be investigated. The method used to clean the conductivity probe (ethanol followed by water) might be a source of nanobubbles[11] which would attach to the electrode and would artificially reduce the electrical conductivity for the gassed case. This would lead to a larger difference between the degassed and gassed cases than is actually the case. However when a parallel set of experiments were run with flat platinum plates, the electrodes were blacked with chloroplatinic acid and lead acetate to prevent bubble formation at the electrode sites and a similar difference was still observed between the two conductivities. If bubbles

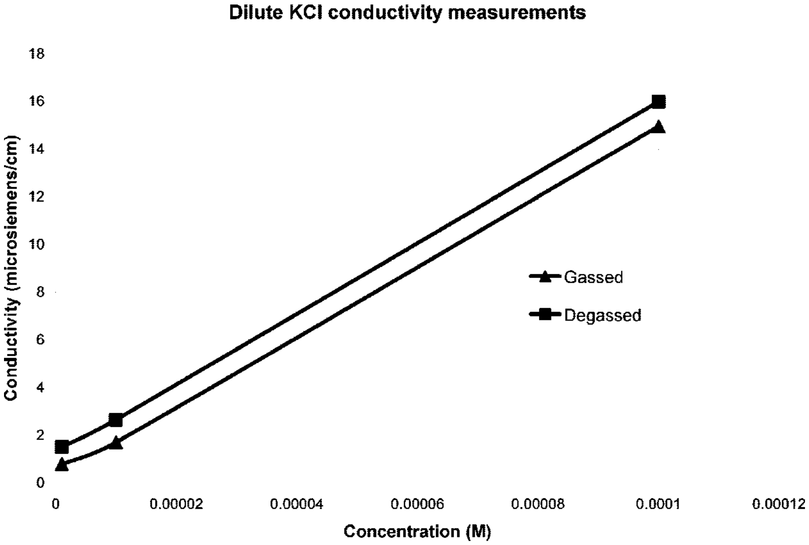

Figure 7. Difference between the degassed and nitrogen purged KCl electrical conductivities for dilute solutions.

TABLE 3: Difference in Electrical Conductivity between Degassed and Nitrogen Purged Potassium Chloride Solutions

concentration of KCl (M)	literature conductivity (μS/cm)[10]	nitrogen purged conductivity (μS/cm)	degassed conductivity (av) (μS/cm)	difference (μS/cm)
1×10^{-6}	–	0.45−0.60	1.51	0.82
1×10^{-5}	–	1.50−1.70	2.65	0.95
1×10^{-4}	14.94	14.94	15.99	1.05
1×10^{-3}	147	146.9	148.2	1.30
5×10^{-3}	717.8	719	720	1.00
1×10^{-2}	1413	1414	1414.5[a]	0.50

[a] Cond 7100e module only had four digit display and 1×10^{-2}M alternated between 1414 and 1415 μS/cm during measurement.

were still forming on these electrodes then this has implications for the entire field of conductivity as nanobubbles would be attaching to all electrodes prepared in this fashion which would effect calibration of electrodes and ultra pure water measurements.

Figure 2 shows that not only is the electrical conductivity of pure water directly related to the extent of dissolved gas removed but interestingly the conductivity increase was quite linear, until extremely low pressures are reached. At this point the conductivity began to rise rapidly. Measuring beyond this point was impossible as the apparatus used for this study could not achieve lower pressures, yet it does suggest that as water structure is less affected by dissolved gas molecules, the conductivity increases more rapidly.

As is known with nitrogen purged water, temperature was found to have a direct effect on the conductivity of degassed water. Figure 3 shows the change in electrical conductivity of a degassed water solution as the temperature was raised incrementally. The tapering off of conductivity as the temperature was raised, for some samples at 60 °C, could have been due to the PTFE O-ring seals failing under these conditions. This would allow a small amount of atmospheric gas to re-enter the vessel over time and so lower the conductivity. A thermal run from 10 to 60 °C often took as long as half an hour, as the temperature had to equilibrate at each increment and it has been previously shown that even a small amount of dissolved gas can suppress the conductivity to a high degree.[1]

Figure 4 demonstrates the similar trends observed for the electrical conductivities of nitrogen purged and degassed water samples, as they were heated. For both samples the electrical conductivity increases exponentially with temperature. The similar trend shown by these two samples suggests that the presence of dissolved gas is entirely responsible for the suppression of the electrical conductivity in nitrogen purged water.

The lowest pressure achieved at 25 °C consistently yielded a value for the electrical conductivity of 1.90 ± 0.1 μS/cm. This value is larger than that reported in the previous study, which suggests that some of the nitrogen used to create a sterile environment above the water was redissolving into the water as the measurements were taken or a lower (vacuum) pressure was achieved here than previously. This value of 1.90 μS/cm agrees with a value reported in 1996 by Bunkin et al. during their spectroscopic study of degassed water.[12] In this work they degassed the water by the conventional boiling-freezing treatment and found the resistivity of doubly distilled water to be 0.5 MΩ cm (which corresponds to an electrical conductivity of 2.0 μS/cm) but they dismissed this increased value as ionic contamination.

To determine if the high electrical conductivity values observed here for degassing were the result of some constant ionic contamination (such as ions leaching from the glass vessel); the solutions were purged with ultra pure nitrogen gas, following degassing. The conductivity, post degassing, was suppressed to the same level that was observed prior to degassing when the atmospheric equilibrated water was purged with nitrogen (Figure 5). Purging with nitrogen and returning the conductivity value to below 0.1 μS/cm indicates that any ionic contamination present was at such levels as not to noticeably effect the conductivity.

It has been shown that the classic literature value of 0.055 μS/cm[1] can be readily achieved by single distilled filtered water being supersaturated with nitrogen gas. Literature values from the SI data book are 0.042 μS cm^{-1} at 20 °C (24 MΩ·cm) and 0.055 μS cm^{-1} at 25 °C (18 MΩ·cm).[4] These values are typically obtained for commercial ultra pure water units such as those produced by Millipore. However, these values appear to correspond to the conductivity of water with CO_2 removed but not nonpolar dissolved gases, such as oxygen and nitrogen. Much higher values are obtained for atmospheric, carbon dioxide equilibrated pure water at about 0.75 μS cm^{-1}.[13] It is interesting that the major water purification company Millipore recently stated that "It is clear that 18.2 MΩ·cm is no longer a 'quality certification' value."[14] This was because latest developments in inductively coupled plasma mass spectrometry ultra trace

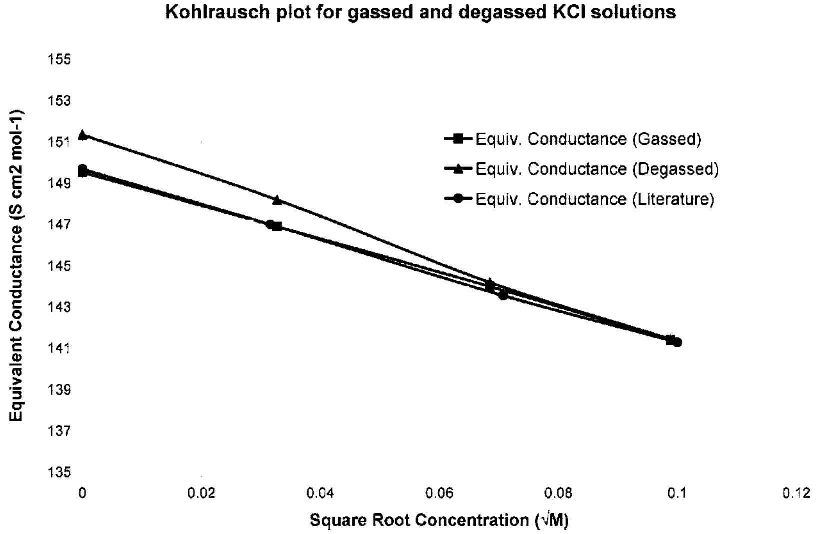

Figure 8. Kohlrausch plot of gassed and degassed molar conductance of potassium chloride solutions.

analysis were pushing back the definition of “pure water”. However, as of 2007, Millipore’s highest quality grade 1 ‘ultra pure water’ has a resistivity of 18.2 MΩ·cm. The water used in the present study was prepared as standard laboratory “single-distilled” water and stored in Pyrex vessels in a laminar-flow cabinet. It is surprising that the values obtained here, simply by thoroughly purging with high-purity nitrogen gas, should give water with conductivity values reasonably close to the best values published in the literature. Other gases were dissolved into the water and a similar suppression of electrical conductivity was observed. It appears that nitrogen and methane are the most effective at lowering the conductivity as the lowest conductivity measurements were achieved using these gases.

Oxygen and argon, although more soluble than methane and nitrogen (Table 2), do not suppress the electrical conductivity to the same extent. Both oxygen and argon possess lower polarizability volumes than nitrogen or methane (Table 2). This suggests that the larger the polarizability volume of a gas, the more it will disrupt the water structure and lower the electrical conductivity. Methane, which has a similar solubility to nitrogen, has a slightly higher polarizability volume. Methane therefore, would be expected to lower the electrical conductivity of water further than nitrogen. Table 2 demonstrates that the average values for water purged with methane were lower than those achieved with nitrogen. Helium, possessing the lowest solubility and the smallest polarizability volume of all gases tested, had the least effect on suppressing the electrical conductivity of water. These results indicate that the polarizability volume of a given gas is a more important indication of its suppressive ability on electrical conductivity in water than the solubility of the gas in water. Propane for example, regardless of its low solubility in water (<200 ppm), would be expected to suppress the conductivity to a greater extent than methane and nitrogen given its much higher polarizability volume (6.3×10^{-30} m^3). These results also show that the accepted electrical conductivity value for industry standard ultra pure water can be generated by purging single distilled laboratory water for half an hour with ultra pure methane gas.

As the conductivity of pure, degassed water was found to be significantly different to the literature values, other physical properties of water might also need to be measured under degassed conditions. If the conductivity is raised upon removal of all of the dissolved gas molecules (as our results have shown) then this points to a significant change in the structure of water. Currently it is understood that water adopts a clathrate-like structure around hydrophobic molecules and removal of these groups (such as dissolved hydrophobic gas) would change the structure. Other physical properties may also change, such as boiling point and as has already been suggested, viscosity. The boiling point of degassed water might be higher as the nucleation sites of the dissolved gas that lower the energy needed to boil (much like boiling chips) have been removed, meaning more energy would be required to boil the water which would raise the boiling point. Another important factor, which may be changed, is the dielectric constant, which is related to the conductivity. If the value of the dielectric constant were to change for degassed water then the ability of salts to dissolve in water would change too. Thus, if the dielectric constant of water were to increase upon degassing, then degassed water would be able to dissolve salts more effectively than ordinary, atmospheric water. Also, as the dielectric constant and viscosity of the water might change upon degassing this might lead to an increase in the electromobility of ions in solution. The results presented here show much more work needs to be carried out into the basic physical properties of degassed water to give a better understanding of the nature of pure water.

The effect of dissolved gas on dilute ionic solutions has also been studied here. In these systems although ionic effects still dominate, the dissolved gas still affects the overall conductivity. The removal of gas was found to raise the electrical conductivity of these ionic solutions by 1 μS/cm. Figure 6 demonstrates that the effect of removing the dissolved gas from the potassium chloride solutions does not affect the trend of the conductivity seen for nitrogen gas purged solutions. That is, the ionic mobility in solution is largely unimpeded by the dissolved gas. However, Figure 7 clearly demonstrates a similar rise in the electrical conductivity of potassium chloride solutions as you remove the gas as was witnessed for the previous water systems without salt. We see from this figure that the conductivity of the solutions is raised slightly from the nitrogen purged values, suggesting that although the dissolved gas does not hinder the ions significantly and removing them still increases the conductivity of the solution. From the Kohlrausch plot in Figure 8, constructed from the gassed and degassed values, we see that there is a noticeable difference in the infinite dilutions values. This difference is 1.9 S cm^2 mol^{-1}, the only difference between the two systems being the addition of nitrogen post degassing. The value calculated from the difference between the degassed and gassed values is more accurate than the difference between the literature and degassed values, as the degassed and gassed values have a slightly higher concentration due to the loss of water during the freeze thaw process. This suggests that either the addition of nitrogen suppresses the conductivity of the ions in solution, forcing their ionic conductivities to be underestimated, or more likely, the addition of nitrogen suppresses the conductivity of water (measured at 1.9 μS/cm), allowing the infinite dilution values to be calculated without the interference of the conductivity of the water.

Conclusions

Improved measurements of the electrical conductivity of highly degassed water yielded a value of 1.90 ± 0.1 μS/cm at 25 °C. However, results obtained at different degassing levels suggest that even higher conductivity levels might be achieved on complete degassing. Dissolved gas was also found to have a noticeable effect on the electrical conductivity of dilute potassium chloride solutions. It was also shown that purging ionic salt solutions with pure nitrogen gas to obtain the infinite dilution values appears to suppress the conductivity of water and allows the molar conductance at infinite dilution to be accurately calculated. The results presented here have ramifications for the production of pure water, the theoretical modeling of water and the measurement of the basic physical properties of water.

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