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Wapreparation of low cost dissolved oxygen strips – a note

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ABSTRACT

Dissolved oxygen refers to the oxygen molecule O_2 that is free or not bounded with other elements that is dissolved in the water bodies. Generally milligrams per litre (mg/L) or percent saturation is the measuring unit of dissolved oxygen. There is lot of chemicals that change colour when reacts with oxygen that is dissolved in the water or solution. The widely used method for detecting dissolved oxygen is titration method which is called Winkler method. The calorimetric method is the basic principle. Microfluidics in combination with paper strip detection can also be the innovative method to develop the dissolved oxygen strips. We will be developing the dissolved oxygen strips soon with those information and new innovative ideas.

KEY WORDS: DO strips, Innovative method, Calorimetric method, low cost strips.

1. INTRODUCTION

Dissolved oxygen refers to the oxygen molecule O2 that is free or not bounded with other elements that is dissolved in the water bodies. There is no similarity between the water molecule H2O and this free oxygen O2 thus it is the independent molecule dissolved in the water. It is dissolved through surface turbulence and diffusion. The purpose of this dissolved oxygen in the water bodies is to act as the source of respiratory gas for the organisms present in the water bodies such as bacteria, invertebrates, plants and fishes. This oxygen is exchanged by the fishes and other small animals like crustaceans using their gills while the plants and photosynthetic bacteria use this oxygen using the process of photosynthesis. Generally milligrams per litre (mg/L) or percent saturation is the measuring unit of dissolved oxygen. The amount of oxygen content in a litre of water is usually referred as milligrams per litre while the percent saturation is the amount of oxygen in a litre of water relative to the total amount of oxygen that the water can hold at the temperature. Every organism requires different level of oxygen supple for example 6mg/l is required for crabs, worms while 15mg/l is required for fishes. Most of the oxygen is also used by microorganism like bacteria and fungi because they use this oxygen for decomposing the waste material thereby recycling the nutrient level in the water bodies.

One of the major factors affecting this dissolved oxygen is temperature because the level of oxygen content is decreased or increased during different temperature for example warmer water has less dissolved oxygen while colder water. During high temperature the water's molecular activity is increased to certain extend which moves away or pushes the oxygen. The cooling machinery uses water to cool them and gives out the thermal discharges in various manufacturing power plants that rises the temperature of the water there by reducing the oxygen capacity of the water bodies. The reduced oxygen is also may be due to the over consumption by microorganism if they are highly populated in the places like sewage, industrial waste deposited areas etc. This is usually referred as Biological oxygen demand (BOD). The fertilizer run off from the farm land is also one of the reasons for the increase in consumption of oxygen by the aquatic plants because the fertilizer makes them to grow faster and hence makes them to consume oxygen more. The climate is the major factor the causes the decrease of oxygen in the lakes, rivers and streams etc because when the climate is so warmer it increases the dissolved oxygen while it is cloudy it decreased the dissolved oxygen by reducing the plant activity of photosynthesis and also cause the death of aquatic plants which in turn increases the growth of microorganism that consumes high oxygen. During morning the presence of oxygen in water is good and sufficient for all aquatic animals and microorganism because they are produced by plants during the photosynthesis but during night time they stop producing the oxygen which in turn consumes it, thus making the dissolved oxygen to come below 4mg/l. This is the minimum concentration required for the consumption of certain fishes that live in warm water like bass, spike and bluegill.

Importance of dissolved oxygen: Dissolved oxygen is the most important factor that maintains the integrity of aquatic life forms. It level is indicator of the proper growth of aquatic plants and purity of the water. If the production of oxygen is less when compared to the consumption then there is the decline in the level of oxygen and animals or fishes which is sensitive to this decline will die soon or weakens faster. There is a range in which the concentration of oxygen should not be too low or too high both cause some effects among the aquatic lives. It the percentage of oxygen is higher than 110 then it causes harmful effect in aquatic lives for example Gas bubble disease is the disease that occurs due to presence of more dissolved gases which blocks the flow of blood through vessels. Mostly invertebrates are mostly affected by this disease when compared to higher level fishes. As mentioned above good dissolved oxygen is necessary for good water quality because purification of the natural stream requires adequate dissolved oxygen for growth of aerobic life forms. When the level of oxygen is below 1ml/l large number of fishes may die within few hours. It is used to test the water quality content in dams and reservoirs. Thus monitoring the

dissolved oxygen in the water bodies is the most important and become necessities for determining the quality of water level.

Monitoring dissolved oxygen: The monitoring refers to the detection of amount of oxygen dissolved in the water. This can be done in various ways such as probes, meters and calorimetric methods etc. The most common method and easy monitor method is dissolved oxygen meter which is an electronic device that uses the probes for detecting the oxygen. The salt solution in probe contains selectively permeable membrane that allows the oxygen present in the water to enter into salt solution which intern changes the electric potential in the solution containing salts. The cable which is connected to meter is used to convert the signals to unit in which the dissolved oxygen can be read that is milligrams per litre. This is very expensive kits but one can measure accurately and quickly along with temperature of the water. The combination of meter and probe is very costly and cost up to 1200 dollars. It is easy to handle and can be used for detecting sample at various sites at the same time. It gives the direct reading and can be easily prone to fragile. The widely used method for detecting dissolved oxygen is titration method which is called Winkler method. The special reagents are mixed with oxygen in sample which forms acid and then it can be titrated against neutralizing agent that causes appearance of coloured solution. The point at which colour change appears is the equal to the amount of oxygen dissolved in the water. The kits of these methods are widely available and it is less expensive when compared to probes and meters. The syringe type titrator, eyedropper and digital titrator are commonly available kits which gives more or less good accurate values. Even though it is less costly than probes and meters it not cheapest method for detecting the oxygen in the water. Thus the simple, easily detectable and cheap method of detecting dissolved oxygen in various water sources is still in research. Thus this paper conveys the method of making a simple, cheap and easily detectable dissolved oxygen strips.

Dissolved oxygen probes in market: There are lots of dissolved oxygen probes in the market. Meng Shan Lin has developed a new type of disposable dissolved oxygen probe using vitamin B12. They developed the electrode using the electrochemical activity of vitamin B12 which helps to sense the oxygen. Chronoamperometry was used to make the disposable dissolved oxygen strip. It can able to detect upto 0.5 mmol L^{-1} ($r = 0.9986$) with the -0.4V. They developed the sensitive method but of which the cost is little higher. They have not been conducted in the natural environment. Marvin J. Johnson also developed an oxygen probe for fermentor which could be stream sterilizable. This is the normal monitoring probe especially for the fermenter. Christopher Langdon has already developed a pulsed electrode to detect the dissolved oxygen. He developed it to overcome the limitation of other electrode and used it to detect at sea water. It has polarographic conventional electrode that was connected to the Chronoamperometry that gives reproducibility of ±0.8 μM. The data acquisition is usually done by the microcomputer which also performs the pulse generation and storage using the software. Thus there is more sophisticated a technique that gives the accurate results are available in market but these are costly and personal care has to be taken while using those probes. Hence there is the need for user friendly and less costly devices to detect dissolved oxygen.

Initiative for dissolved oxygen strips: The inspiration to development of dissolved oxygen strips idea arose on seeing the pH strips this changes colour depending up on the hydrogen content in the solution. This is due to the present of colour changing compounds which is pre coated within the strips.

Changing compounds is present naturally in plants, flowers and some vegetables which change colour depending upon the pH in the soil. These natural things contains substance called Anthocyanins which is mostly found in petals, cabbage juice, rhubarb and berries is coated in the paper and now commercially used as pH strips. This idea gives the inspiration to develop dissolved oxygen strips because monitoring the oxygen level is important and now the cost of measuring the oxygen levels in water is at higher rate. So for smaller labs and students we are developing the strips that will be easier to handle at low cost like pH strips. Hence the principle for this technique will be the calorimetric technique. There is lot of chemicals that change colour when reacts with oxygen that is dissolved in the water or solution one such is Phenosafranine which is colourless in normal state which on oxidised turns into red colour. Indigo carmine is colourless in normal state that on oxidised gives the blue colour. It used to measure the concentration up to 15 ppm. Resazurin turns into purple pink from pale blue on reaction with oxygen that is dissolved in the solution or water. Methylene blue is both oxidation and reduction indicator and retains colour under oxidised state and becomes colourless under reducing state. The reduction of methlylene blue can be done with glucose. The commercially available kits that use the colorimetric principle have the chemical called rhodazine D which has ability to detect even very low concentrations of dissolved oxygen. This forms deep rose coloured solution when reacts with dissolved oxygen which is not affected by sulphide or salinity in the water. Hence with these chemicals it is possible to detect the dissolved oxygen level based on the intensity of the colour.

2. CONCLUSION

Thus this paper focuses on the development of dissolved oxygen strips that detects the accurate results in minimum cost. Microfluidics in combination with paper strip detection can also be the innovative method to develop

the dissolved oxygen strips. We will be developing the dissolved oxygen strips soon with those information and new innovative ideas.

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