Towards a more efficient CDS recipe

method for making chlorine dioxide solution using the smallest amount of sodium chlorite

Background

Several methods have been published for making chlorine dioxide solution in the home. Most of these use readily available equipment that is likely to be found in a kitchen or for purchase in hardware stores.

There are two-stage methods, single-stage methods, rapid methods, in-fridge methods and methods involving tubing, pumps and separate reaction vessels. Some involve equipment that is usually only found in a laboratory.

The standard concentration for chlorine dioxide solution is 3 000 ppm (parts per million) or 0.3%. Some recipes and methods produce higher concentrations; 4 000 ppm—which is simpler on the maths—is quite common but concentrations up to 25 000 ppm can be produced. As the concentration increases, more ClO_2 is left in solution with the reagents because (without pumps and concentrators) the concentration of ClO_2 will equalise between the solutions.

Given that the CDS (of whatever concentration) will be further diluted before use in most cases, it makes sense to produce a concentration that is only as strong as you might ever use undiluted. 3 000 ppm is therefore a good strength to aim at. It is possible to use this method to make stronger or weaker solutions but 3 000 ppm is a good, standard concentration used in the protocols.

The published methods can use more than twice the amount of $NaClO_2$ necessary, mainly due to only partially acidifying the solution but also because a significant amount of ClO_2 is left in the reaction chamber. This may be useful in other ways but is generally not as useful as the CDS itself.

This paper is not the place to delve into the benefits of CDS over MMS and CDH and there are people who would advocate for these and claim various benefits. This paper is addressed to those who wish to make CDS at home in a safe and efficient manner.

Having tried various methods and considered many more. the author developed a set of criteria of importance, carried out several experiments, ran calculations to understand the chemical balances involved and used an understanding of chemical dynamics to inform the development of this protocol.

The result is a method that is simple, safe, flexible and efficient. Do send feedback and questions to realising.potential@icloud.com .

Aims & fundamentals

- time is not too much of an issue; this is something that is produced every month or so rather than on a daily basis or ad hoc in a hurry
- … but quicker is better; interventions over several days can be hard to schedule
- safety is paramount
- single-stage process is preferable
- full acidification of the $NaClO_2$ is most efficient
- chemical reactions run quicker when they are hotter (~double for every 10K)
- a large surface area encourages escape of formed gas
- … and absorption of the gas into the receiving water (that becomes the CDS)
- minimum air spaces keep vapour pressures high, encouraging absorption into the water
- tall walls can hinder the flow of gas
- dissolved ClO_2 remains in the reagent chamber
- … in balance with the ClO_2 in the air space
- … and the ClO_2 in the water, now CDS
- … which should be at the lowest practical concentration
- therefore minimising the volume of reagents improves efficiency
- … which in turn implies that high concentrations of reagents are better
- chemical reactions happen faster with more concentrated reagents
- chemical reactions slow down in the presence of their products
- … therefore ensuring that the products (notably ClO_2 in this case) can readily escape from the reaction vessel is important for full and speedy reactions

Based on all of these points, the search was focussed on finding a large, shallow container (to provide large surface areas and small air volumes), a very shallow reaction vessel—preferably floating—and concentrated reagents.

The most concentrated form of sodium chlorite is the dry powder or flakes and the most concentrated form of sulphuric acid readily available is 36%. Reacting these two together can cause spitting as gas is evolved within the matrix of the flakes. The method described, although based on dry $NaClO_2$ powder, dissolves it in a minimal amount of water to avoid this problem. The reaction is still quite violent and care must be taken that the main container remains sealed and that the acid is introduced at a rate that allows the reaction to remain contained. The whole process (or at least the reaction phase) should be conducted outside if at all possible or at least in a well ventilated area, preferably with an extractor fan. Consideration should be given to the consequences of the lid popping off and understanding the amount of ClO_2 gas that would be released in such a situation. High concentrations of ClO_2 gas are irritating to the eyes and mucus membranes and such exposure should be avoided.

Equipment and reagents needed

The following is a list of the equipment that the author uses; you may need to substitute items with what is available in your situation using the principles noted in the Aims and fundamentals section.

- two litre, empty, plastic, rectangular ice cream container with a small hole in the lid
- plastic lid that floats with 20ml liquid in it (this is the reaction vessel)
- 10ml syringe
- shot glass
- old plastic tooth brush (for stirring)
- accurate weighing scales (10g to one or two decimal places)
- 1½ litres of warm water (70°C) (The temperature is not critical; the author uses this as a compromise between speed of reaction, softening of the plastics and because it is easy to obtain from the hot water dispenser)
- 10g $NaClO_2$ powder/flakes
- 6ml 36% HCl solution
- refrigerator

The various items can be seen in the photograph above.

Method

- Put 1½ litres of warm water into the main container
- Weigh 10g of $NaClO_2$ into the shot glass
- Add about 10ml of the warm water (more if necessary) and stir until dissolved

- Float the reaction vessel on the warm water and gently pour in the sodium chlorite solution

- Place the lid on the main container with the hole over the reaction vessel
- Measure the acid into the syringe

- Place the syringe into the hole in the lid and gently squeeze a drop or two in; you will hear the reaction taking place
- The lid will bulge as the gas is generated; wait some minutes until the bulge subsides and then gently add more acid
- You will find that you can add more acid each time and the warm water will quickly dissolve the ClO_2 gas but ensure that the lid does not pop off
- Once all of the acid has been injected into the reaction chamber, leave the container alone for a few hours
- The syringe can be removed and the hole sealed with a piece of tape
- When the reaction has completed and the container cooled to near room temperature, place the unit in the fridge, preferably overnight
- Once chilled (below 11°C), carefully remove the container from the fridge and in a well ventilated space, carefully remove the lid and the reaction chamber with the reagents, checking that the colour of the solution in the reaction chamber is similar to that in the main chamber
- Decant the CDS into bottles, seal and return to the fridge
- The reagents can be used separately as usual for cleaning acid-tolerant surfaces