(54) Title: MONITORING APPARATUS AND METHODS

(57) Abstract

This invention relates to monitoring apparatus and methods and, in particular, to apparatus and methods for monitoring the concentration of an aqueous solution. A body (14) is tethered in a fully immersed position in the solution by a wire (15) and the force variations in the wire (15) caused by variations in concentration of the solution are monitored.
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Monitoring Apparatus and Methods

This invention relates to monitoring apparatus and methods and, in particular, to apparatus and methods for monitoring the concentration of an aqueous solution contained within a vessel. It further includes apparatus for varying the concentration of such an aqueous solution.

Many bulk chemicals are supplied to industry at specific concentrations, which reflect the general commercial use of that chemical. However, whilst such an approach enables the chemicals to be supplied at an economic price, for many uses the selected concentrations maybe inappropriate. This can be particularly problematic if it is necessary to use solutions of very accurate concentrations and/or to use such solutions on a continuous basis.

One example of such a process, which utilises hydrogen peroxide in an aqueous solution, is described in our International Patent Application No. WP-A-94/01885. In that case it has been found that the hydrogen peroxide concentration has an important effect on the layers deposited and, for the most part, the concentrations required are greater than those usually available.

From one aspect there is provided apparatus for monitoring the concentration of an aqueous solution comprising, a vessel for containing the solution, a body having a density distinct from the density of the solution in the expected working range, means for tethering the body in the vessel so that the body is fully immersed in the solution in

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use and means for monitoring the effective weight of the tethered body to provide an indication of concentration.

It will be appreciated that the gravitational weight of the body will be counteracted by an up-thrust which is directly proportional to the density of the solution and this in turn is proportional to the concentration. Thus the effective weight of the body (i.e. the gravitational weight less the up-thrust) is representative of the concentration of the solution and the range of effective weights can be duly calibrated.

The body may be any shape, but in a preferred embodiment it is spherical or part spherical and it may be tethered by a flexible element, such as a wire.

The monitoring means may comprise a weighing machine and the body may act on the weigh pan through the tethering means. Where the body is more dense than the solution, it may be suspended from the under surface of the weigh pan of an electronic weighing machine or, via a pulley or other mechanism, to the upper of the pan. In either case the force on the pan will be determined by the concentration of the solution. In another embodiment the body may be less dense than the solution and the apparatus may further comprise a pulley or other mechanism whereby the upward force on the body is transmitted to act on the weigh pan to an extent determined by the concentration of the solution. Alternatively in any of the cases the monitoring means may monitor the tension in the tether means and other equivalent approaches would be satisfactory.
The density may also vary with temperature and in that case means for measuring the temperature of the solution may be provided and the apparatus may further include means for compensating the indication proved by the monitoring means in accordance with the measured temperature.

From another aspect the invention consists an apparatus for varying the concentration of an aqueous solution means for changing the concentration of the solution in response to the indication of concentration provided by the monitoring means.

The concentration changing means may include a heater, for heating the solution and/or means for bubbling an inert gas through the solution. Additionally or alternatively they may include means for diluting the solution. In the case where gas is bubbled through the solution, control means may be provided for switching off the gas at intervals and carrying out the step of monitoring during those intervals.

As has been indicated above the previously described apparatus is suitable for use with commercially available solutions, such as the aqueous solutions of hydrogen peroxide. In such cases, the solution will normally be driven into the vessel using an inert gas.

From a further aspect the invention consists in a method for monitoring the concentration of an aqueous solution in a vessel comprising monitoring the effective weight of a body having a density greater than the density of the solution in the expected working range, which is
tethered to be fully immersed in the solution and providing an indication of the concentration of the solution from the weight.

The method may also include monitoring the temperature of the solution and compensating the indication in accordance with the measured temperature.

From yet a further aspect the invention may include a method of varying the concentration of an aqueous solution, including monitoring the concentration in accordance with the method described above and varying the concentration of the solution in response to the indication of the concentration provided by the monitoring means.

Thus if the concentration is too low, the solution may be heated to evaporate off water and this evaporation may be assisted by bubbling inert gas through the solution; if it is too high the solution may further be diluted.

The particular advantage of the method and apparatus described above is that the monitoring can be carried out on a continuous or intermittent basis and provides an output, which can readily be used for automatic control.

Although the invention has been described above it is to be understood that it includes any inventive combination of the features set out above or in the following description.

The invention may be performed in various ways and a specific embodiment will now be described, by way of example, with reference to the accompanying drawing in which:
Figure 1 a schematic view of apparatus for varying the concentration of a solution in a vessel, including apparatus for monitoring the concentration of that solution; and

Figure 2 is the equivalent view of an alternative arrangement.

Apparatus for varying the concentration of an aqueous solution is generally indicated at 10 in the Figure and includes monitoring apparatus for monitoring the concentration of the solution, which is generally indicated at 11.

The monitoring apparatus 11 comprises a vessel 12, for receiving the aqueous solution via an inlet 13; a spherical body 14, which is suspended by means of a wire 15; an electronic weighing machine 16 having a weigh pan 17 to which the wire 15 is attached; a thermistor 18; and a processing and control unit 19 having an output 20.

In use, the body 14 is immersed in the solution 21, so that the solution 21 provides an up-thrust against the body 14, which is dependent on the density of the solution 21. This up-thrust reduces the effective weight of the body 14 and it is this weight which is measured by the electronic weighing machine 16. The measured weight is fed to the unit 19 on line 22. Similarly the output of the thermistor 18 is fed, on line 23, to the unit 19.

The unit 19 can be provided with calibration or look-up tables which indicate the concentration, for a particular temperature, which corresponds to the measured effective weight of the body 14. This concentration is provided at output 20 as a numerical signal; a simple indication that
the desired concentration has been achieved or as a feedback signal for the purposes described below.

It will be understood that the density of the body 14 should be more than the anticipated density of the solution within the working range, so that the body 14 will not float, otherwise the wire 15 will not be maintained in tension. The tension within the wire 15 could equally be monitored to provide the desired indication.

Most conveniently, the monitoring apparatus 11 is used as part of a concentrating apparatus 10. This further includes a heater 24, an outlet 25 and an inlet 26 for inert gas. In either case the vessel 12 is conveniently provided with a lid 27 to prevent any noxious fumes escaping. The lid may have a vent 28 for connection to suitable fume outlet.

In a typical example concentrating apparatus 10 is used in the following manner. Bulk commercially-supplied chemical is pushed into the vessel 12, by an inert gas such as nitrogen. Once the vessel is sufficiently full for the body 14 to be fully immersed, the heater 24 is switched on to evaporate water from the solution and hence increase the concentration of the solution. At the same time nitrogen may be introduced through the submerged inlet 26 so that it bubbles upwardly through the solution 21 speeding the rate of evaporation. Periodically the unit 19 switches off this supply of nitrogen and takes a reading of the output on lines 22 and 23 to compute or look up the instantaneous concentration of the solution. This value may be displayed or it may be compared with a target value. When the target
value is reached an alarm may be sounded or the signal on line 20 may be used to switch off the heater. If a very precise concentration is required, then the output at 20 may be used as a feedback signal to control the heater and/or the nitrogen and it may be also used to control a supply of water through the inlet 13 so that dilution is also possible. The output on line 20 may further control the outlet 25, so that once the desired concentration is reached the vessel can be emptied through outlet 25 and the process started again.

Figure 2 shows an alternative construction in which the body 14 is less dense than the solution and the wire 15 passes around a pulley 29 so that the body is tethered in an immersed position. In either construction the wire 15 may pass over a further pulley (not shown) to connect to the upper surface of the pan 17.
Claims

1. Apparatus for monitoring the concentration of an aqueous solution comprising, a vessel for containing the solution, a body having a density distinct from the density of the solution in the expected working range, means for tethering the body in the vessel so that the body is fully immersed in the solution in use and means for monitoring the effective weight of the tethered body to provide an indication of concentration.

2. Apparatus as claimed in claim 1 wherein the body is spherical or parts spherical.

3. Apparatus as claimed in claim 1 or claim 2 wherein the monitoring means comprises a weighing machine and the body acts on the weigh pan through the tethering means.

4. Apparatus as claimed in claim 3 wherein the body is more dense than the solution and is directly suspended from the weight pan.

5. Apparatus as claimed in claim 3 wherein the body is more dense than the solution and is suspended by a pulley or other mechanism whereby it lifts the weigh pan to an extent determined by the concentration of the solution.

6. Apparatus as claimed in claim 3 wherein the body is less dense than the solution and further comprising a pulley or other mechanism whereby the upward force on the body is transmitted to act on the weigh pan to an extent determined by the concentration of the solution.
7. Apparatus as claimed in claim 6 wherein the means for tethering is a cable or the like and passes around a pulley or other bearing surface located beneath the operational position of the body.

8. Apparatus as claimed in any one of claims 3 to 7 wherein the weighing machine is electronic.

9. Apparatus as claimed in claim 1 and claim 2 wherein the monitoring means monitors tension in the tethering means.

10. Apparatus for varying the concentration of an aqueous solution comprising monitoring apparatus as claimed in any one of the preceding claims and automatic means for changing the concentration of the solution in response to the indication of concentration provided by the monitoring means.

11. Apparatus as claimed in claim 10 wherein the concentration changing means includes heater means for heating the solution.

12. Apparatus as claimed in claim 10 or claim 11 wherein the concentration means includes means for bubbling an inert gas through the solution.

13. Apparatus as claimed in any one of claims 10 to 12 wherein the concentration changing means includes means for diluting the solution.

14. Apparatus as claimed in any one of the preceding claims where the solution is an aqueous solution of hydrogen peroxide.

15. A method of monitoring the concentration of an aqueous solution in a vessel comprising monitoring the effective
weight of a body having a density greater than the density of the solution in the expected working range, which is tethered to be fully immersed in the solution and providing an indication of the concentration of the solution from the effective weight.

16. A method as claimed in claim 16 further including monitoring the temperature of the solution and compensating the indication in accordance with the measured temperature.

17. A method of varying the concentration of an aqueous solution including monitoring the concentration by the method claim 15 or claim 16 and varying the concentration of the solution in response to the indication of the concentration by the monitoring means.
**INTERNATIONAL SEARCH REPORT**

**A. CLASSIFICATION OF SUBJECT MATTER**

| IPC | G01N9/10 | G01N9/36 | G05D11/06 |

According to International Patent Classification (IPC) or to both national classification and IPC.

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

| IPC | G01N |

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched.

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

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<td>Y</td>
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**X** Further documents are listed in the continuation of box C.  

**X** Patent family members are listed in annex.

**Date of the actual completion of the international search**

23 October 1996

**Date of mailing of the international search report**

30.10.96

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