CLAIMS

1. A measurement method for a precipitation speed of an inorganic salt in water, characterized by comprising the following steps:

S1: obtaining a type of an inorganic salt precipitated in water to be measured, obtaining a known initial value of one selected from inorganic carbon methyl orange alkalinity (Cmalk(t_0)), a pH(t_0) value, and total dissolved inorganic carbon (DIC(t_0)) in the water at a starting time (t_0), obtaining total dissolved solid (TDS), and obtaining an initial content of an element of a target inorganic salt contributing to non-inorganic carbon methyl orange alkalinity;

S2: continuously measuring a change value of a carbon dioxide concentration (CO_2w) in the water to be measured over time or continuously measuring a change value of a carbon dioxide concentration (PCO_2) in a gas phase in balance with the water to be measured over time in a closed constant-temperature and constant-pressure environment; when PCO_2 is measured, obtaining the change value of the carbon dioxide concentration CO_2w in water over time according to the carbon dioxide Henry constant Kh; and obtaining carbon dioxide concentrations $CO_2w(t_0)$ and $CO_2w(t_1)$ at the starting time (t_0)and a subsequent time (t_1);

S3: combining the known initial value obtained in S1 with the $CO_2w(t_0)$ obtained in S2, calculating the remaining two of Cmalk(t_0), the pH(t_0) value and DIC(t_0) based on the known initial value and $CO_2w(t_0)$ according to formulas (1), (2) and (3), and determining Cmalk(t_1), DIC(t_1) and pH(t_1) based on the Cmalk(t_0) and $CO_2w(t_0)$ values obtained at the starting time (t_0), the type of inorganic salt precipitated in water to be measured and the $CO_2w(t_1)$ measured in step S2, the determination of Cmalk(t_1), DIC(t_1) and pH(t_1) being performed according to a calculation defined for the target inorganic salt, thereby obtaining the precipitation amount of the target inorganic salt during a time interval between the starting time (t_0) and the subsequent time (t_1); and

S4: obtaining the precipitation speed of the target inorganic salt according to the precipitation amount obtained in step S3 during the time interval between the starting time (t_0) and the subsequent time (t_1),

wherein

$$DIC=CO_2w\times(1+k'_1/(H^+)+k'_1\times k'_2/(H^+)\text{^}2), \quad \text{----(1)}$$

$$Cmalk = 50000\times CO_2w\times(k'_1/(H^+)+2k'_1\times k'_2/(H^+)\text{^}2), \quad \text{----(2)}$$

$$pH= -\log(H^+) \quad \text{----(3)}$$

where DIC is the total dissolved inorganic carbon concentration in the water (mol/L), CO_2w is the carbon dioxide concentration in the water to be measured (mol/L), Cmalk is the inorganic carbon methyl orange alkalinity in the water (mg/L, calculated as calcium carbonate), H^+ is a hydrogen ion concentration in the water to be measured (mol/L), k'_1 is a first dissociation constant of carbonic acid, and k'_2 is a second dissociation constant of carbonic acid.

2. The measurement method according to claim 1, characterized in that the target inorganic salt is calcium carbonate, and there are no other ions contributing to the inorganic carbon methyl orange alkalinity

in the water to be measured, and wherein the determination of $Cmalk(t_1)$, $DIC(t_1)$ and $pH(t_1)$ in the step S3 comprises the following steps:

S311: knowing $Cmalk(t_0)$ and $CO_2w(t_0)$ at the starting time (t_0), and calculating $H^+(t_0)$ and $DIC(t_0)$ at the starting time (t_0) according to formulas (2) and (1);

S312: knowing $CO_2w(t_1)$ at the subsequent time (t_1), calculating $H^+(t_1)$ at the subsequent time (t_1) according to formula (5), calculating $Cmalk(t_1)$ at the subsequent time (t_1) according to formula (2), and calculating $DIC(t_1)$ at the subsequent time (t_1) according to formula (4),

$$(DIC(t_0)-DIC(t_1))\times 100\times 1000 = (Cmalk(t_0)-Cmalk(t_1)) \quad --(4)$$

$$2\times CO_2w(t_0)-2\times CO_2w(t_1) = CO_2w(t_1)\times k'_1/H^+(t_1)-CO_2w(t_0)\times k'_1/H^+(t_0) \quad --(5)$$

S313: calculating the calcium carbonate precipitation amount according to formula (6)

calcium carbonate precipitation amount $CaCO_3 = (DIC(t_0)-DIC(t_1))$ * 10^5 --(6)

wherein, the unit of calcium carbonate precipitation amount $CaCO_3$ is mg/L.

3. The measurement method according to claim 1, characterized in that the inorganic salt precipitated is calcium phosphate, and no ions are contributing to the inorganic carbon methyl orange alkalinity other than the inorganic carbon methyl orange alkalinity contributed by orthophosphate in the water to be measured, and wherein the determination of $Cmalk(t_1)$, $DIC(t_1)$ and $pH(t_1)$ in the step S3 comprises the following steps:

S321: knowing of $Cmalk(t_0)$ and $CO_2w(t_0)$ at the starting time (t_0), and calculating $H^+(t_0)$ and $DIC(t_0)$ at the starting time (t_0) according to formulas (2) and (1);

S322: knowing $CO_2w(t_1)$ at the subsequent time (t_1), calculating $DIC(t_1)$ and $H^+(t_1)$ at the subsequent time (t_1) according to formula (7), calculating $Cmalk(t_1)$ at the subsequent time (t_1) according to formula (2),

$$DIC(t_0) = DIC(t_1) = CO_2w(t_1)\times(1+k'_1/H^+(t_1)+k'_1k'_2/(H^+(t_1)\text{^}2)) \quad --(7)$$

S323: knowing $Tp(t_0)$ at the starting time (t_0), obtaining $DIP(t_0)$ according to formula (9), calculating $Pmalk(t_0)$ according to formulas (10)-(12), calculating $DIP(t_1)$ according to formulas (8)-(12), and calculating calcium phosphate precipitation amount according to formula (14);

$$(DIP(t_0)-DIP(t_1))/2\times 2\times 50\times 1000 = Cmalk(t_0) + Pmalk(t_0) - Cmalk(t_1) - Pmalk(t_1) \quad --(8)$$

$$DIP = Tp/95/1000 \quad ----------(9)$$

$$Pmalk = (PO_4^{3-})\times 2\times 50000 + (HPO_4^{2-})\times 1\times 50000 ----------(10)$$

$$(PO_4^{3-}) = Tp/95/1000\times kp_1\times kp_2\times kp_3/((H^+)\text{^}3 + (H^+)\text{^}2\times kp_1 + (H^+)\times kp_1\times kp_2 + kp_1\times kp_2\times kp_3) \text{-}(11)$$

$$(HPO_4^{2-}) = (PO_4^{3-})\times(H^+)/kp_3 ----------(12)$$

Calcium phosphate precipitation amount $Ca_3(PO_4)_2=(DIP(t_0)-DIP(t_1))/2\times 310\times 1000$ ----(14)

wherein Pmalk is the inorganic phosphorus methyl orange alkalinity mg/L, calculated as calcium carbonate, DIP is the total dissolved inorganic phosphorus concentration mol/L, and Tp is the total dissolved inorganic phosphorus concentration mg/L, calculated as PO_4^{3-}; kp_1 is the first ionization constant of phosphoric acid, kp_2 is the second ionization constant of phosphoric acid, and kp_3 is the third ionization constant of phosphoric

acid; the unit of calcium phosphate precipitation amount $Ca_3(PO_4)_2$ is mg/L.

4. The measurement method according to claim 1, characterized in that the target inorganic salt is magnesium silicate, and no ions are contributing to the inorganic carbon methyl orange alkalinity other than the inorganic carbon methyl orange alkalinity contributed by silicate in the water to be measured, and wherein the determination of $Cmalk(t_1)$, $DIC(t_1)$ and $pH(t_1)$ in the step S3 comprises the following steps:

S331: knowing $Cmalk(t_0)$ and $CO_2w(t_0)$ at the starting time (t_0), and calculating $H^+(t_0)$ and $DIC(t_0)$ at the starting time (t_0) according to formulas (2) and (1);

S332: knowing $CO_2w(t_1)$ at the subsequent time (t_1), calculating $DIC(t_1)$ and $H^+(t_1)$ at the subsequent time (t_1) according to formula (7), calculating $Cmalk(t_1)$ at the subsequent time (t_1) according to formula (2),

$$DIC(t_0) = DIC(t_1) = CO_2w(t_1)\times(1+k'_1/H^+(t_1)+k'_1k'_2/(H^+(t_1)\text{^}2)) \quad --(7)$$

S333: knowing $Tsi(t_0)$ at the starting time (t_0), obtaining $DISi(t_0)$ according to formula (16), calculating $Simalk(t_0)$ according to formulas (17) and (18), and calculating $DISi(t_1)$ according to formulas (15)-(18), and calculating the magnesium silicate precipitation amount according to formula (19);

$$(DISi(t_0) - DISi(t_1))\times 2\times 50\times 1000 = Cmalk(t_0) + Simalk(t_0) - Cmalk(t_1) - Simalk(t_1) \quad --(15)$$

$$DISi = Tsi/60/1000 \quad -- (16)$$

$$Simalk = 50000\times(Si(OH)_3O^-) \quad --(17)$$

$$(Si(OH)_3O^-)= DISi/(1 + H^+/Ksi) \quad --(18)$$

magnesium silicate precipitation amount $MgSiO_3= (DISi(t_0)-DISi(t_1))\times 2\times 50\times 1000$ -- (19)

wherein DISi is the total dissolved inorganic silicon content mol/L, Tsi is the total dissolved inorganic silicon content mg/L, calculated as SiO_2, Simalk is the inorganic silicon methyl orange alkalinity mg/L, calculated as calcium carbonate, and Ksi is the dissociation constant of silicic acid; and the unit of magnesium silicate precipitation amount MgSiO3 is mg/L.

5. The measurement method according to claim 1, characterized in that the target inorganic salt is colloidal silicon, and no ions are contributing to the inorganic carbon methyl orange alkalinity other than the inorganic carbon methyl orange alkalinity contributed by silicate in the water to be measured, and wherein the determination of $Cmalk(t_1)$, $DIC(t_1)$ and $pH(t_1)$ in the step S3 comprises the following steps:

S341: knowing $Cmalk(t_0)$ and $CO_2w(t_0)$ at the starting time (t_0), and calculating $H^+(t_0)$ and $DIC(t_0)$ at the starting time (t_0) according to formulas (2) and (1);

S342: knowing $CO_2(t_1)$ and $Cmalk(t_1)$ at the subsequent time (t_1), calculating $DIC(t_1)$ and $H^+(t_1)$ at the subsequent time (t_1) according to formula (7), calculating $Cmalk(t_1)$ at the subsequent time (t_1) according to formula (2);

$$DIC(t_0) = DIC(t_1) = CO_2(t_1)\times(1+k'_1/H^+(t_1)+k'_1k'_2/(H^+(t_1)\text{^}2)) \quad ----(7)$$

S343: knowing $Tsi(t_0)$ at the starting time (t_0), obtaining $DISi(t_0)$ according to formula (16), calculating $Simalk(t_0)$ according to formulas (17) and (18), and calculating $DISi(t_1)$ according to formulas (16)-(18) and (20), and calculating the colloidal silicon precipitation amount according to formula (21);

$$(DIsi(t_0) - DIsi(t_1))\times 1\times 50\times 1000 = -(Cmalk(t_0) + Simalk(t_0)) +(Cmalk(t_1)+Simalk(t_1)) \quad --(20)$$

$DISi = Tsi/60/1000$ --(16)

$Simalk = 50000 \times (Si(OH)_3O^-)$ --(17)

$(Si(OH)_3O^-) = DISi/(1 + H^+/Ksi)$ --(18)

colloidal silicon precipitation amount $SiO_2 = (DISi(t_0) - DISi(t_1)) \times 1 \times 60 \times 1000$ --(21)

wherein DISi is the total dissolved inorganic silicon content mol/L, Tsi is the total dissolved inorganic silicon content mg/L, calculated as SiO_2, Simalk is the inorganic silicon methyl orange alkalinity mg/L, calculated as calcium carbonate, and Ksi is the dissociation constant of silicic acid; the unit of the colloidal silicon precipitation amount SiO_2 is mg/L.

6. The measurement method according to claim 1, characterized in that the step S2 comprises: measuring a carbon dioxide gas concentration PCO_2 in a closed detector, wherein a gas circulation pump and a carbon dioxide concentration in a gas phase detector are provided in a loop of the closed detector, and continuously recording the carbon dioxide gas concentration PCO_2 during measurement; then converting the carbon dioxide gas concentration PCO_2 into the carbon dioxide concentration CO_2w in the water according to Henry's law.

7. An electronic device, characterized by comprising: a processor; a memory, and a computer program stored in the memory and operable on the processor, when the computer program is executed by the processor, the measurement method for the precipitation speed of an inorganic salt in water according to any one of claims 1 to 6 is implemented.

8. A computer-readable storage medium, characterized in that a computer program is stored in the storage medium, and when the computer program is executed by a processor, the measurement method for the precipitation speed of an inorganic salt in water according to any one of claims 1 to 6 is implemented.

9. A measurement system for the precipitation speed of an inorganic salt in water, characterized by comprising a closed detector for measuring the carbon dioxide concentration and the electronic device according to claim 7, the electronic device further comprising an input-output module, the output end of the closed detector being in signal communication with the input-output module of the electronic device.

10. The measurement system according to claim 9, characterized in that the closed detector comprises a test container, a carbon dioxide detector, a first constant-temperature heating unit, and a gas circulation pump, wherein water to be measured is placed in the test container, an inlet of the carbon dioxide detector is in communication with the test container, an outlet of the carbon dioxide detector is in communication with the test container via the gas circulation pump to form a pipeline loop for recirculating carbon dioxide, and the first constant-temperature heating unit is provided on the test container to control the temperature of the measured water in a constant temperature state.