FilterSorb SP3

Introduction: Part I

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INTRODUCTION SP3

(S) SCALE (P) PREVENTION (3) $Ca(HCO_3)_2$ soluble changes
Temporary Hardness
into

Calcium Carbonate	+	Pure Water	+	Carbon dioxide
$CaCO_3$	+	H_2O	+	CO_2

This is the **Definition** of **FILTERSORB SP3**

Science and the Scientifc Method of SP3

A. Science is the description of world based on

MEASURABLE **FACTS** , **[DATA]** and the formulation of **TESTABLE**

Explanations How the hard water operates **WORKS**

Science and the Scientifc Method of SP3

FACTS HARD WATER

[DATA] Calcium Carbonate $CaCO_3$

" a very useful materials"

"and the FORMULATION Calcium and Magnesium compounds are both M = Metals **Ca** or **Mg** same group 2 (periodic table), similar properties"

TESTABLE explanations

O	Oxide	CaO = Calcium Oxide MgO = Magnesium Oxide
OH	Hydroxide	$Ca(OH)_2$ = Calcium hydroxide $Mg(OH)_2$ = Magnesium hydroxide
HCO_3	Hydrogen Carbonate	$Ca(HCO_3)_2$ = Calcium hydrogen carbonate $Mg(HCO_3)_2$ = Magnesium hydrogen carbonate
CO_3	Carbonate	$CaCO_3$ = Calcium carbonate $MgCO_3$ = Magnesium carbonate

WATCH WATER a Water Company

Science and the Scientifc Method of SP3

B. **Assumptions (axioms) of science:**

1. The water behaves chemically, governed by a natural order
   (**H^+**) Hydrogen + (**OH^-**) Hydroxides = **H_2O**
2. There is a **cause** and effect relationship behind every **SCALE** happening

- One might ask, where did the scale come from?
- What was the original cause?

CAUSE

Water + Carbon dioxide + Calcium + Magnesium + Oxides + Hydroxides +

Hydrogen carbonate, made water hard is called

TEMPORARY HARDNESS

$H_2O + CO_2 +$ Ca + Mg + O + OH + HCO_3 and after saturation $Ca(HCO_3)_2$

And the Temporary Hardness exist is a scientific fact.

HARD AND SOFT WATER

1. **The scientific method to test Hard water vs. Soft water**

SOAP TEST

It is very important to know what “Soap” is?

“SOAP” is not “detergent“

Soap in hard water makes “scum” but not detergents. **NOTE** detergents usually give a very good lather with any water. With soft water you never get rid of soap from your body and left over soap causes **skin diseases** (Read Case Study). All detergents are SOAPLESS. Scum is because of **Gypsum**, which are mainly Calcium Sulfate $CaSO_4$.

SOAP TEST

The term of “Soapy Soap” is not a joke!

SOAP is “Natural Sodium Stearate”

The chemistry of “Scum” formation

Calcium Sulfate + Sodium Stearate → Calcium Stearate + Sodium Sulfate
(Hardness) (soap) (scum)

Formulation the scientific method

$$CaSO_4 + 2C_{17}H_{35}COONa \longrightarrow Ca(C_{17}H_{35}COO)_2 + Na_2SO_4$$

Conclusion Testable explanation of “**Clear Yellow**” Test Kit

• A precipitation reaction is generally defined as the formation of **insoluble solid,** one before the **SP3** system and after the **SP3** system

Clear Yellow Test	Inlet	Outlet
Condition	Not dissolved	Dissolved
Visual appearance	Turbid	Clear

WATCH WATER a Water Company

Testable Explanations

C. The scientific method: Answering questions

Using TESTABLE explanations

1. **Ask questions why SP3 is better?**
   a) Why water softener treatment is so expensive?
   b) Why do human beings need water?
   c) What causes high blood pressure?
   d) Why calcium is so important?
   e) Why magnesium deficiency is dangerous?
   f) What causes cancer?
   g) How do soft water causes cardiovascular diseases?
   h) What is a saturated solution and solute in water?
   i) What causes eczema?

Testable Explanations

2. **SP3** treatment offers a tentative explanation that can be **TESTED**

Solubility of Calcium and Magnesium compounds and their reactions

- **Solvent:** the liquid that dissolves the material in test.
- **Solute:** the material which is to be dissolved in a solvent in test bottle.
- **Solution:** the result of the dissolving in the test water.

Solute + Solvent = Clear solution

- **Solubility:** to what extent a test powder (solute) will dissolve
- **Soluble:** the material or test powder will dissolved in good water
- **Insoluble:** not soluble, will not dissolve in a **SP3** water i.e. Calcium Sulfate ($CaSO_4$) and Magnesium Sulfates ($MgSO_4$)

Note: The solution of CO_2 (aq.) is sometimes described as "Carbonic acid" H_2CO_3 but this **does not really exist**!

CO_2 (aq.) + H_2O $\leftrightarrow$ H^+(aq.) + HCO_3^-(aq.)

Testable Explanations

Solubility of Calcium and Magnesium compounds and their reactions ***(continues)***

•**Saturated:** means saturated solution in one in which solute will not dissolve

❖ Calcium sulfate **saturated** water will not dissolve test powder

❖Calcium and magnesium oxides or hydroxides are **soluble** in H_2CO_3 water till gets **saturated** $Ca(HCO_3)_2$

These are the major cause of scale and alkaline solutions

❖ Calcium carbonate and magnesium carbonate both are insoluble in water, but they are readily dissolves in acids. pH of the water remains same, alkalinity of the water remains same.

FACTS

C. Step 3: Collect the **DATA** **FACTS**

Note: Using **Ion-exchange** for hard water **increase costs** because **sodium chloride** or **hydrochloric acid** is needed to make a regeneration and this leads to high sodium ions in water or hydrogen ions which reduces the pH of water.

- $CaCO_3 + 2\mathbf{HCl} \longrightarrow Ca^{2+}(Cl^-)_2 + H_2O + CO_2$
- $CaCO_3 + 2\mathbf{NaCl} \longrightarrow Ca^{2+}(Cl^-)_2 + H_2O + 2Na^+$

However, a **negative point**! **Sodium** ions and **hydrogen** ions both causes high blood pressure and acidic body cells and can cause cancer and this is not a Hypothesis or a Theory but a Scientific fact. The test study should be identical in all ways.

FACTS

Case Study:

Acids solutions have a pH of < 6.8. These are quite often of salts, which are themselves formed from neutralizing acids and bases. That is the reason the pH sinks when crystallization takes place. Example: Template Assisted Crystallization (TAC). Because all acids from hydrogen ions in the water and with this the remaining ions that is Calcium (Ca^{2+}) and Chlorides (Cl^{2-}) becomes the salt of $CaCl_2$ and the same reaction takes place with magnesium (Mg^{2+}) and chlorides (Cl^{2-}) becomes $MgCl_2$ and this is true.

FACTS that in all **acids** there are more H ions and with chlorides it makes HCl hydrochloric acid. The **main cause** and the only cause **of corrosion** and it is a scientific **FACT** .

Nucleation Assisted Crystallization (NAC)

• **NAC** Is different than other crystallization process of water crystallization. A solid **heterogeneous catalyst** that reacts with a water and gaseous/solutions.

• The reaction occurs on the **SP3** surface which is a glass surface coated on Calcium and ceramic beads. The reactants are absorbed onto the catalyst **SP3** surface at the “active sites” cracked glass surface. These reactants are physical adsorbed and very “weakly” bounded to the **SP3** surface. When the high concentrations of the reactants are very close to each other and weakening the original molecular bonds within the reactants ions are separated in seconds with a great success of “fruitful” collision.

Hydrogen Carbonate Ion (HCO_3^-)

The hydrogen carbonate ion as HCO_3

$$Ca(HCO_3)_2 \xrightarrow{\textbf{SP3}} CaCO_3 + H_2O + CO_2$$

insoluble calcium carbonate, Pure Water and CO_2 as gas and on the surface of **SP3** the carbonate ions CO_3^{2-} acting as a base, gains two protons to form

$$H_2O + CO_2 + Ca^{2+}$$

these are separated on the surface of **SP3**, CO_2 in this formula is acting as supersaturated CO_2 and the Ca starts Nucleation process and becomes crystals.

Hydrogen Carbonate Ion (HCO_3^-)

Incidentally, H_2O is a neutral oxide because its pH is 7. Logistically the oxonium/hydrated proton ion concentration equals to the hydroxide ion concentration.

$$2H_2O \leftrightarrow (H_3O^+) + (OH^-)$$
(And this is a scientific fact)

The strength of adsorption is very important to have a very smooth surface and SP3 has a glass surface.

WATER $\longleftrightarrow$ Oxonium / Hydrogen ion + Hydroxide ion

But, in this reaction, water acts as but both ACID and BASE i.e, one water molecule acid donates a proton to another water molecule which becomes an oxonium ion (hydrated proton) and another water molecule (base) simultaneously accepts a proton!

<u>Therefore, water is an amphoteric oxide</u>: That is it reacts as both a proton acceptor and a proton donator.

Hydrogen Carbonate Ion (HCO_3^-)

Now the hydrogen carbonate ion HCO_3^- Can act as a carbonate ion both as ACID with a Base or act as a base with an acid, such behavior is described as amphoteric

HCO_3^- acting as a base, accepting a proton from an acid.

$$HCO_3^- + OH^- \longrightarrow H_2O + CO_2$$

HCO_3^- acting as an acid donating a proton to the hydroxide ion base

MORE SIMPLE: the reactant $Ca(HCO_3)_2$ bounding to the **SP3** catalyst glass surface (chemisorptions/adsorption) must be very strong to apart reactant ions as fast as possible but enough to handle all ions and the products to “escape” from the **SP3** surface its called (desorption process).

Nucleation ⟶ Adsorption

Assisted ⟶ Desorption

Crystallization ⟶ in one process

SP3 functionality

In **SP3** **NAC** process the very expensive ceramic beads are used. Glass coating is very unusual on the catalyst but it is holding to keep the maximum surface area to give the greatest and therefore the most efficient rate of reaction. This means the catalyst **SP3** must be physically supported by glass surface distributed with very high temperature on ceramic support. All other medias available in the industry expands and have very less active sites on the catalyst surface. It considerably reduces the efficiency of the product.

Example: Template assisted media (TAC) expands to double of its original size loosing the Active sites for reaction.

SP3 Poisoning

Actives Sites: Not all the surface of the media is effective due to minute imperfections in Ca^{2+} crystal at the ionic level. For any catalytic surfaces, this is desired to have cracked surfaces before they are much more effective than the rough expanded ones.

Important: **SP3** catalyst poisoning should be avoided if at all possible.

- High **Copper** and high content of **Iron** can cause these impurities, as they can be bounded on the **SP3** active sites of the surface. It considerably reduces the efficiency of the **SP3**, especially as the most effective **SP3** catalyst sites bind impurities the strongest, competing with the reactant $Ca(HCO_3)_2$ ions.

- Hydrogen sulfides poisons the **SP3** media, so precautions should be taken that water contains no sulfur.

- Commercial systems have to replace media every 5 - 7 years.

Conclusion

Case Studies:

- **Boilers**
- **Heat exchangers**
- **Cooling Towers**
- **Commercial applications**

❖ **Reminder:** What **FILTESORB SP3** is and how does **it** work?

❖ **SP3** is a media that alters the rate of scale prevention without any regeneration or use of chemicals. It takes part in the reaction and change hardness into non effective and harmless crystals.

FILTESORB SP3

End of Part I