Identification of chemical form of carbon released from type 304L and 316L stainless-steel powders in alkaline and acidic solutions under low-oxygen conditions

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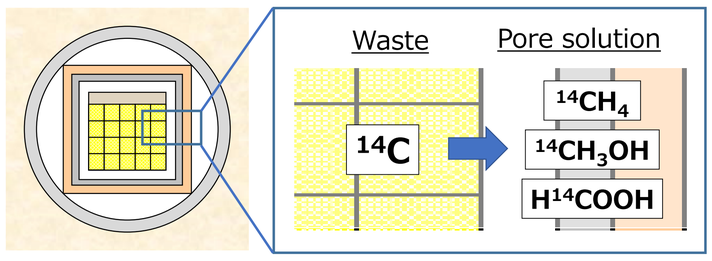
Introduction

- The chemical form of ^{14}C released from the low-level waste (irradiated stainless steel) is a key parameter in the safety assessment of the sub-surface disposal system in Japan.

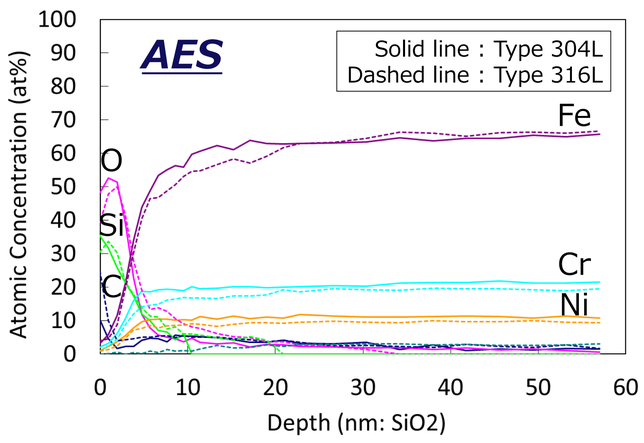


Objectives

- Identify a chemical form of stable carbon released from non-irradiated stainless steel in acidic and alkaline solutions under low oxygen conditions.

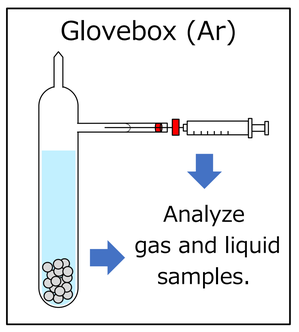
Materials

- Type 304L and 316L stainless-steel powders
  - Water-atomized powders
  - Particle size : < 150μm (type 304L)
    < 45μm (type 316L)



Immersion experiment

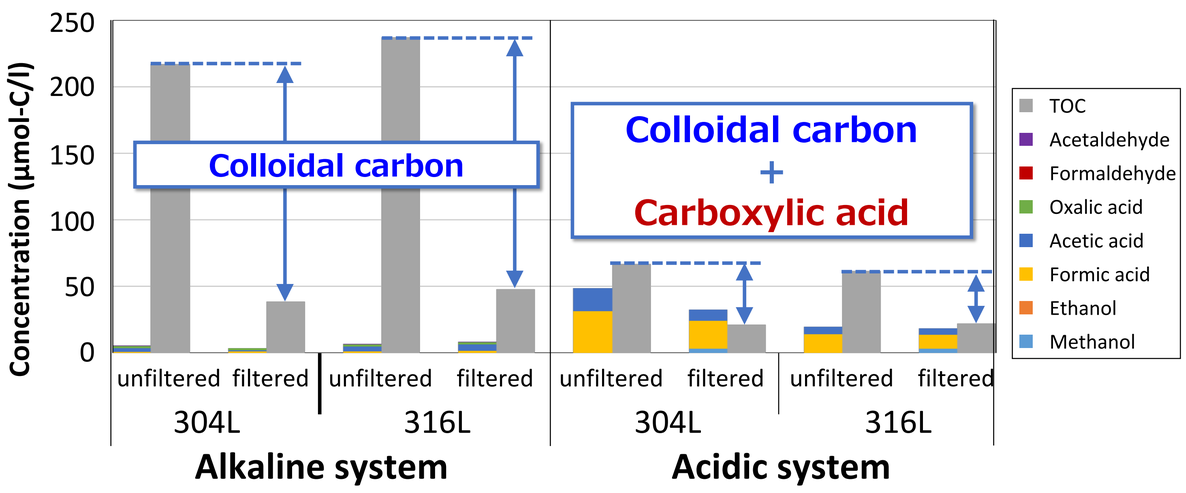
	Alkaline system	Acidic system
Mass of powder (g)	70	70
Vol. of solution (ml)	70	70
Type of solution	50mM NaOH (pH ~12)	50mM HCl (pH ~2)
Temperature (°C)	25	25
Duration (day)	25	20



- The collected liquid samples were divided into unfiltered and filtered samples.
- The filtered sample were filtrated using an ultrafiltration membrane (10,000 MWCO).

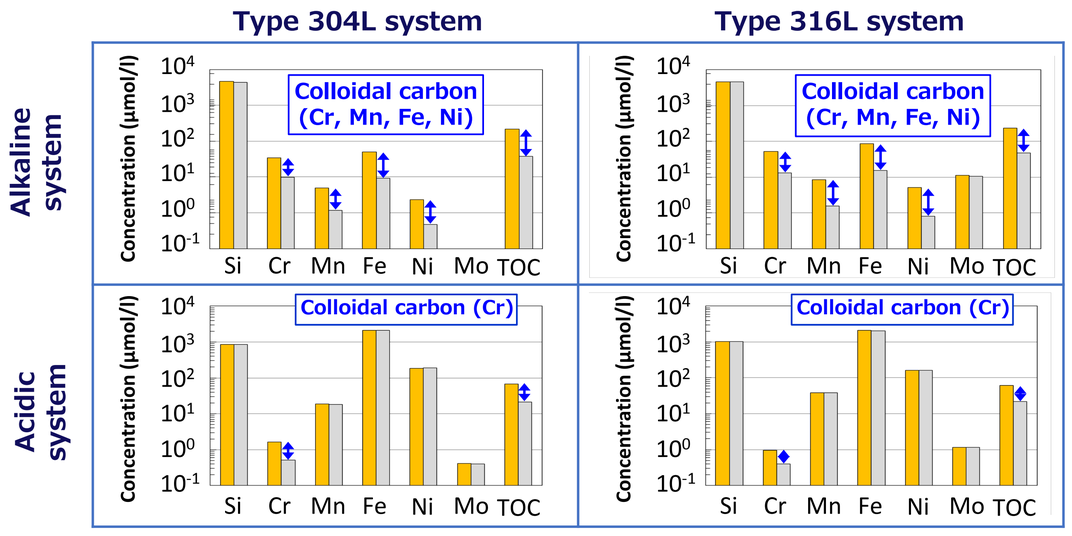
Liquid analysis results

Carbon species



- Colloidal carbon may be mainly formed in alkaline systems.
- Colloidal carbon, formic and acetic acids may be formed in acidic systems.

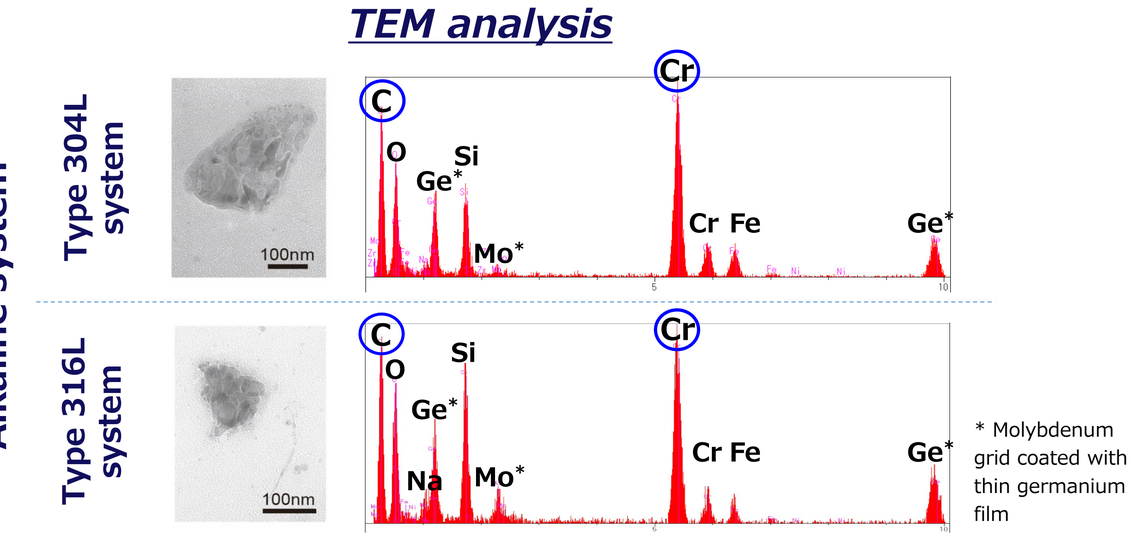
Other elements and TOC



- The chemical composition of the colloidal carbons appeared to be different between alkaline and acidic systems.

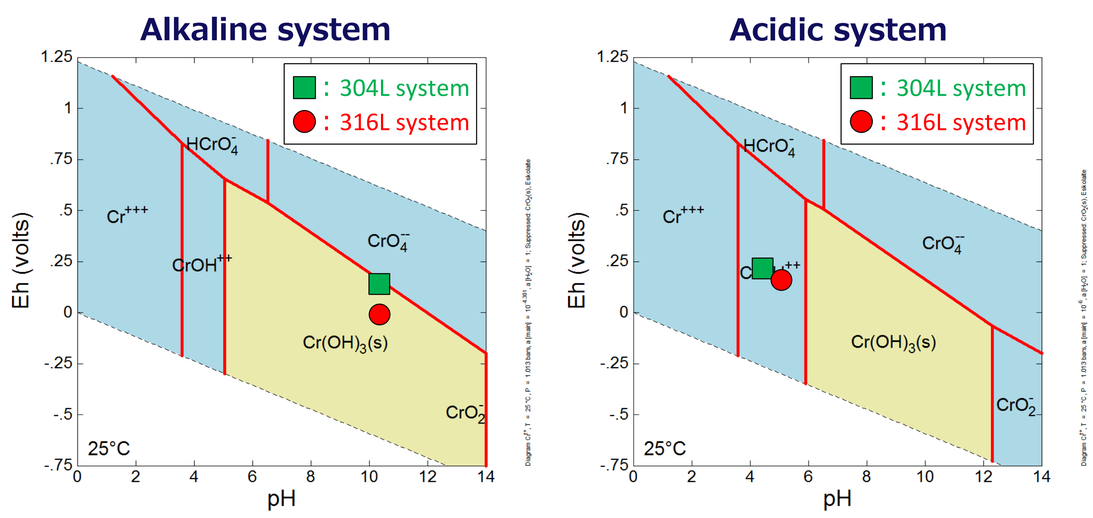
What is the colloidal carbon ?

TEM analysis



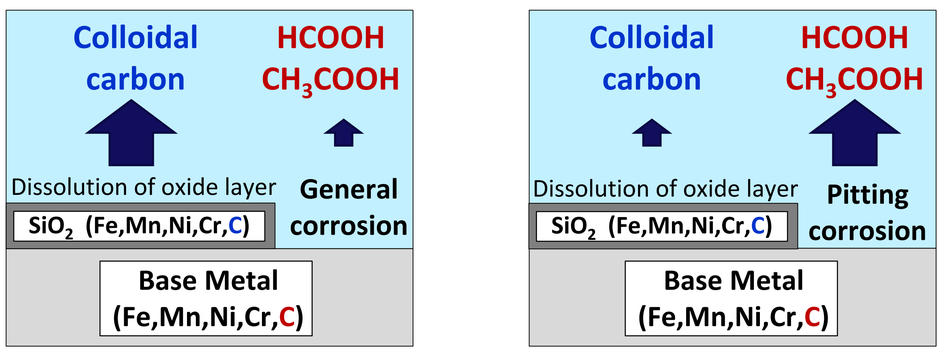
- Carbon was accompanied by Fe, Cr, Si and O in colloidal particles.
- The colloidal carbon may be formed by interactions between C and Cr.

Thermodynamic calculation



- Formation of hydroxide species isn't necessarily an immediate cause of the formation of colloidal carbon.

Why is the chemical form different in alkaline and acidic systems ?



- We speculate that the difference of the site where carbon exist may affect the chemical form carbon.
  - **Colloidal carbon** originates from a silicon oxide layer, and
  - **Formic and acetic acids** originate from a base metal.
- A silicon oxide layer can easily be dissolved thermodynamically in alkaline systems but not in acidic systems.
- A corrosion rate at the interface of base metal in acidic systems is expected to be higher than in alkaline systems. This is because that we used a HCl solution and the pitting corrosion occurred in acidic systems.

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