Development and Application of Eco-friendly Oil Stimulant on Oil Spill Control Training

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Background & Motivation

• For recent 20 years, the world average annual number of oil spills is 21 cases/year (Kim, 2013)
• Problems (e.g. economic loss of a nation, residents and ecological damage) are occurred.
• The goals of this research are (1) evaluation of oil simulation materials that are currently available during training exercises and (2) determination of their effectiveness, advantages, disadvantages, and permitting requirements.

Requirements for the desirable oil spill stimulants

• Properties should be similar to oil and an environmentally friendly.
  Material property / floating / provision / recovery / distinguishing / not harmful to the environment
  Recycle ocean wastes and Reuse as foodstuffs for aquarium animals

Fish meal as a solid stimulant

• A brown powder obtained by drying the fish or fish trimmings, often after cooking, and then grinding it.
• Composed of 60–72% of protein, 10–20% of ash, and 5–12% of fat (IFFO, 2011).
• Rich in a lot of EPA and DHA, which are called as omega-3 fatty acid (Cho and Kim, 2010).
• Has 2 functions; (1) solid simulants for response training and (2) growth accelerator for aquarium animals.

Fish oil as a liquid stimulant

• Fishery production has been increasing from 2010. (statistics)
• Except for edible parts of squid, fish guts are occupied over 20% (Kang, 1993).
• Especially fat, vitamin B, minerals, and omega-3 are more than 40% in squid guts (Kang, 1993).
• The problem of response training for oil spills to use fish (squid) oil is fishy smell, so this research focus on deodorization and utilization of it.

Development and test of oil simulants for response training

1. Experiment process for development of simulants

   ◆Solid simulants

   ◆Liquid simulants

   • Fish odor cause substance : free fatty acids, phosphates, and extra odor components.
   • Decoiling process : removal of free fatty acids
   • Utilization of Ginger, coffee grounds, charcoal, MSG.

   (1) Experimental group : squid oil-dispersant(20% of oil), and Control group : only squid oil.
   (2) Dispersant was sprayed on squid oil with a sprayer, and stirred for 5 mins, resulting in dispersant and squid oil were reacted very well with the naked eye.
   (3) The average absorption rate was almost 19.5 times of self-load.
   (4) Experimental group : squid oil+dispersant(20% of oil), and Control group : only squid oil.

   2. Simulation test of oil simulants (5t tank)

   (floating/moving/absorption/recovery)

   ◆Result of solid simulants: 1-2cm of fried mixture (1:1, v/v) shows best

   ◆Result of liquid simulants: MSG shows the best for deodorization

   ◆The main odor components of squid oil is phosphate, and deodorization using MSG shows the best performance.

3. Complementary experiments

   ◆Tests for (1) dispersant (general SG-1000), and (2) various oil absorbents

   ◆Biodegradation analysis

   (100ml of seawater (from west sea of Korea) with 0.1mL of squid oil was incubated at 17.5ºC with 200rpm, and observed whether the squid oil was degraded by the ocean microorganisms or not. → Squid oil was totally degraded.

4. Safety evaluations

Ocean Eco-toxicalogical Evaluation

• Utilization of microalgae / invertebrate / larval fish for growth inhibition test and acute toxicity test.
• Based on this data, the amount of oil simulants is decided, considering about the amount of the ocean.

NOEC: No Observation Effective Concentration
*EC/LC 50 : Concentration of being half of a population by a material

Area  NOEC  LC50

General items
- Mineral oil / cyanide / phenol / chrome / zinc / copper / cadmium / mercury / organic phosphorus / arsenic / lead / nickel

Specific items
- Polychlorophenolin (PCB) / raphthelane / phenantheme / anthracene / benz[a]pyrene / fluoranthene / benz[a]anthracene / benz[b]fluoranthene / total polycyclic aromatic hydrocarbons (PAHs)

5. Material property (a liquid stimulant)

<table>
<thead>
<tr>
<th>Items</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kinetic viscosity (40ºC)</td>
<td>28.34 mm/s</td>
</tr>
<tr>
<td>Kinetic viscosity (100ºC)</td>
<td>6.57 mm/s</td>
</tr>
<tr>
<td>Cleveland Open Cup (C.O.C)</td>
<td>228 ºC</td>
</tr>
<tr>
<td>Pour Point</td>
<td>-7.5 ºC</td>
</tr>
<tr>
<td>X-Ray sulfur analysis</td>
<td>0.12 mass %</td>
</tr>
<tr>
<td>Brookfield viscosity (A/2/100, 20ºC)</td>
<td>98.4 mPa.s</td>
</tr>
<tr>
<td>Water (Karl-fisher method)</td>
<td>6.379 mg/kg</td>
</tr>
<tr>
<td>Specific gravity (15/4ºC)</td>
<td>0.927</td>
</tr>
<tr>
<td>API degree</td>
<td>21.06</td>
</tr>
</tbody>
</table>

6. Field test for the final experimental simulants (Busan, in Korea)

• Product : 400 kg of solid simulants produced by EP (extruded pellet) process / 100 L of liquid simulants.
• Equipment : 9 training vessels, 60 m of oil fence, 20 kg of oil absorbents, and 2 of oil skimmers
• Solid : a mixture of fish meal, flour, yeast, and yellow coloring / floating for 2 cm / 2 hours
• Liquid : refined squid oil with gardenia yellow (100:1, v/v)

Solid : appropriate for control training using oil fence

Liquid : appropriate for control training using oil skimmer