

OIL SPILL CONTROL USING SMART SORPTION DEVICE

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OIL SPILL CONTROL USING SMART SORPTION DEVICE

by

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DEDICATED TO
SHASHANK
AND MY FAMILY

CERTIFICATE

This is to certify that the thesis entitled “**oil spill control using smart sorption device**” being submitted by **Ms. Neha Bhardwaj** to the Department of Chemical Engineering, Indian Institute of Technology, New Delhi in partial fulfillment of the requirements for the award of the degree of **Doctor of Philosophy** in Chemical Engineering, is a record of bonafide work carried out by her. She has worked under my guidance and supervision and has fulfilled the requirements, which to my knowledge has reached requisite standard for the submission of the thesis.

The research reports and results presented in thesis have not been submitted in part or full to any other university or institute for the award of any degree or diploma.

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Neha Bhardwaj

ABSTRACT

Consequences of oil-spills in the past have given multiple dimensions to research in predicting the fate of a given spill and of possible efficient counter measures to be undertaken for the same. One of these fields deals with the development of effective sorbents for oil-spill remediation. Newer materials with enhanced sorption abilities are being developed; however, most of these materials cannot be directly used as sorbents in their native or original form. The material needs to be assembled in a structure or form such that it can efficiently sorb the oil, can survive the oceanic currents and other prevailing environmental conditions without itself becoming a source of secondary pollution, and can be easily collected after it has sorbed the oil. An additional desirable attribute can be its reusability – if the sorbed oil can be removed completely from the structure without altering its structure/geometry, it can be reused multiple times.

The main objective of the current investigation is to develop and design an oil-sorbent device having all the above-mentioned attributes, for the sorption of crude oil and its emulsions with sea water and deionized water. This device has been designed to comprise of the following four components; porous styrene butadiene rubber, PU foam, pH responsive polyelectrolyte gel, and polypropylene netting. The components have been rendered porous by a novel technique of incorporating and solidifying colloidal gas aphrons (CGAs). The components of the device have been evaluated as per the ASTM for their suitability as sorbents. pH responsive polyelectrolyte gels for sorption of crude oil and weathered oil (W/O emulsions) were synthesized and analyzed for their sorption capacity and reusability. The gels showed recyclability up-to 25 cycles of swelling and collapse.

Each component plays a specific functional role in the overall performance of the device. The device has an oleophilic surface for preferential oil sorption. The polyelectrolyte gel housed within the device is responsible for the bulk of sorption and contribute to the reusability feature of the device. The PU foam is responsible for maintaining the buoyancy at saturation and for promoting efficient transfer of fluid into the device. The device has a high sorption capacity, good oil adhesion, retention, and buoyancy. It has a sufficient mechanical strength at saturation, and could be actuated and aligned using an external magnet. This would enable efficient retrieval of the sorbent units after complete sorption, thus minimizing the chances of creating secondary pollution.

सार

अतीत में तेल-फैलाव के परिणामस्वरूप, दी गई फैल के भाग्य की भविष्यवाणी में अनुसंधान के लिए कई आयाम दिए गए हैं और इसके लिए किए जाने वाले संभावित कुशल काउंटर उपायों की भविष्यवाणी की गई है। इन क्षेत्रों में से एक तेल-फैल उपचार के लिए प्रभावी शर्करा के विकास के बारे में है। उन्नत क्षमताओं के साथ नई सामग्री विकसित की जा रही है; हालांकि, इनमें से अधिकतर सामग्रियों को सीधे उनके मूल रूप में शर्करा के रूप में उपयोग नहीं किया जा सकता है। सामग्री को एक संरचना या रूप में इकट्ठा किया जाना चाहिए, जैसे कि यह तेल के कुशलता से शर्बत कर सकता है, समुद्री धाराओं और अन्य प्रचलित पर्यावरणीय स्थितियों से बच सकता है बिना खुद को द्वितीयक प्रदूषण का स्रोत बनाते हुए, और इसे आसानी से इकट्ठा किया जा सकता है। एक अतिरिक्त वांछनीय विशेषता इसकी पुनः प्रयोज्यता हो सकती है - यदि इसकी संरचना / ज्यामिति को बदलने के बिना संरचना से पूरी तरह से हटाया जा सकता है, तो इसे कई बार पुनः उपयोग किया जा सकता है।

वर्तमान जांच का मुख्य उद्देश्य कच्चे तेल के शर्षण और समुद्र के पानी और विआयनीकृत जल के साथ इसके तेल-वितरित अवशेषों के लिए सभी उपर्युक्त विशेषताओं वाले एक तेल-शर्बत डिवाइस को विकसित करना और डिजाइन करना है। यह डिवाइस निम्नलिखित चार घटकों के शामिल करने के लिए डिजाइन किया गया है; झरझरा स्टायरिन ब्यूटाडियन रबड़, पी ऊ फोम, पीएच प्रति संवेदनशील पोलिएक्ट्रोलाइट जेल, और पॉलीप्रोपीलीन की जाली। इस घटक को कोलाइडेशन गैस एफ़रन्स (सीजीएस) को शामिल और ठोस बनाने की एक नई तकनीक द्वारा झरझरा दिया गया है। उपकरण के घटकों को एएसटीएम के अनुसार शर्बत के रूप में उनकी उपयुक्तता के लिए मूल्यांकन किया गया है। क्रूड ऑयल और वेदरड तेल (पानी / तेल इमल्शन) के स्रापण के लिए पीएच प्रति संवेदनशील पोलिथैलेक्ट्रोलाइट जेल को संश्लेषित किया गया और उनके शर्षण क्षमता और पुनः प्रयोज्यता के लिए विश्लेषण किया गया। जेल ने सूजन और पतन के 25 चक्रों तक रीसाइक्लिबिलिटी दिखाया।

प्रत्येक घटक डिवाइस के समग्र प्रदर्शन में विशिष्ट कार्यशील भूमिका निभाता है। युक्ति अधिमान्य तेल शर्पोशन के लिए एक ओलेफिलिक सतह है। डिवाइस के अंदर स्थित पॉलिएक्ट्रोलाइट जेल, सोर्सिंग के थोक के लिए जिम्मेदार है और डिवाइस की पुनः प्रयोज्यता सुविधा में योगदान देता है। पी ऊ फोम संतृप्ति पर उछाल बनाए रखने और डिवाइस में द्रव के कुशल हस्तांतरण को बढ़ावा देने के लिए जिम्मेदार है। डिवाइस में एक उच्च शर्षण क्षमता, अच्छा तेल आसंजन, प्रतिधारण और उछाल होता है। यह संतृप्ति पर पर्याप्त यांत्रिक शक्ति है, और एक बाहरी चुंबक का उपयोग करके क्रियान्वित और गठबंधन किया जा सकता है। यह पूरी तरह से शर्षण के बाद शर्बत इकाइयों के कुशल पुनर्प्राप्ति को सक्षम करेगा, इस प्रकार द्वितीयक प्रदूषण पैदा करने की संभावना को कम करेगा।

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LIST OF ABBREVIATIONS

S. N.	Abbreviation	Title
1.	SBR	Styrene butadiene rubber
2.	PU	Polyurethane
3.	CGAs	Colloidal gas aphrons (microbubbles)
4.	PP	Polypropylene
5.	PPG	Polyoxypropylene glycol
6.	PUD	Polyurethane diol
7.	TDI	Toluene 1,4 diisocyanate
8.	SLS	Sodium lauryl sulphate
9.	CTAB	Cetyl Trimethyl Ammonium Bromide
10.	PTFE	Polytetra fluoroethylene
11.	PET	Polyester (PET)
12.	PA	Polyamide (PA),
13.	PO	Polyolefin (PO),
14.	PB	Polybutadiene (PB),
15.	PS	Polystyrene (PS)
16.	PVC	Polyvinyl chloride (PVC)

17.	AA	Acrylic acid
18.	PAA	Polyacrylic acid
19.	PAM	Polyacrylamide
20.	NMBA	N, N' Methylenebisacrylamide
21.	EGDMA	Ethylene glycol dimethacrylate
22.	HCL	Hydrochloric acid
23.	NaOH	Sodium hydroxide