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Sustainable method for degrading hydrocarbons

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ABSTRACT

Conventional treatment of crude oil contamination in open water of chemical dispersants, churning, burning, and soaking has limited effect and in-itself is potentially hazardous. We sought to provide an advanced bio-based green and sustainable chemistry solution that is safe and effective. A novel formula (EcoBioClean®) of proprietary microorganisms, enzymes, catalysts and nutritive components was constituted as a non-toxic rapid-impact remediation, reverse-engineering and bioconversion system. The formula transformed a crude oil slick within minutes into punctate particles resembling ground black pepper. A 21-day post treatment analysis using GC-MS confirmed the North Alaskan Slope Crude had become a nutrient-rich broth containing valuable elements such as choline, fatty acids, Carotene, Vitamin C, Iron, Vitamin E, Copper, Magnesium, Manganese, Phosphorus, Potassium, Zinc, Vitamin D and more than 15 amino acids. Upon contact EcoBioClean® initiates the conversion of crude oil into bio-available nutrient-rich marine food. The result is a benefit to marine life, the ecosystem, the environment, and the economy.

1. Introduction

Each year over 1.3 million gallons (493,000 l) of crude oil are spilled or leak into US waterways with millions more globally (Thompson, 2010). In 2010 alone BP spilled over 200 million gallons (757.8 million liters) of crude oil into the Gulf devastating greater than 68,000 square miles and spending over $60 billion US dollars in related clean-up costs (NY Times Associated Press, 2012). Despite the large sums invested, the problems associated with traditional site clean-up are far from solved. Moderately effective conventional technologies such as combustion to burn off the top layers of oil, spinners that churn or mobilize, soakers or booms, and chemical dispersants that reduce the particle size of crude, have been unable to restore many sites to the standards set by environmental regulations for protection of public health and the environment. Adding chemical dispersants to a chemical disaster is not only counter-productive, it creates an “out of sight – out of mind” state-of-affairs by allowing dispersants to force these toxins to the ocean floor or to deposit toxin-soaked clean-up materials into landfills. Several components of hydrocarbons also belong to the family of carcinogens and neurotoxic organic pollutants threatening public health.

No matter how many preventative measures may be available there will continue to be crude oil and petro-chemical spills due to accidents on drilling rigs, human failure, degradation of underground piping, containment materials, erosion, natural disasters, shifting ocean floors, or terrorist attacks. Driven by stringent “green” laws including natural resource preservation the Environmental Protection Agency (EPA) in the United States has asked giant oil producers to employ safer measures for crude oil spill cleanup (EPA.gov Recent Impact Report-Protecting American Families and Workers from Hazardous Chemicals). Other countries employ similar regulatory guidelines to protect the environment.

Accordingly, we have employed nontoxic rapid reduction technology, EcoBioClean®, which biochemically transitions toxic hydrocarbons into beneficial molecules such as choline, fatty acids, Carotene, Vitamin C, Iron, Vitamin E, Copper, Magnesium, Manganese, Phosphorus, Potassium, Zinc, Vitamin D and more than 15 amino acids rapidly consumed by aquatic and ground life. Some of these elements exist naturally as original molecules locked into animal, vegetable, mineral particles that comprise fossil fuel, others are part of the EcoBioClean® proprietary formula that stimulates rapid consumption by indigenous as well as complementary microbial, fungal, and algae species. Like human body systems, marine ecosystems maintain biochemical health through metabolic processes that insure vital nutrient balance and the elimination of toxins. EcoBioClean® was developed based on the concept that these processes can be extrinsically engineered to reconstitute the ability of a hydrocarbon-damaged ecosystem to recover homeostasis after a major oil spill. This green biotechnology supports the marine “immune” response and its ability to effectively abate disruption to its biochemical balance, acting to clean, preserve and nourish the environment rather than to poison it. In this way the technology we describe here provides a solution to currently

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ineffective and potentially dangerous crude oil clean-up methods.

Discovery of EcoBioClean by the principal of a start-up company described herein also provides the opportunity to illustrate the challenges and barriers small business entities face throughout development of their products. These will be discussed together with creative suggestions to remove barriers and improve the process for such entities in bringing their discoveries into the public domain for the public good.

2. Methods

EcoBioClean® is a proprietary formula containing select groups of naturally existing surfactant, solvent and emulsifier producing microbes and fungi that communally use fossil fuel as a food source while thriving in warmer or colder temperatures, or aerobic and anaerobic environments. To this formula are added necessary exogenous nutrients, prebiotics that nourish probiotic strains, chemical bond breaking enzymes and other harmless naturally occurring bio-components, catalysts, and carriers that enable them to destroy the contaminants by rapid consumption of the food sources in this material.

2.1. Theoretical construct

Current crude oil clean-up and management technologies are largely unsuccessful because hydrocarbons are treated as oils with processes to emulsify, burn or soak, rather than to deconstruct their complex structure. Essentially crude oil is fossil fuel. Although far-removed from its origins, it is a composition of various devitalized prehistoric organic substances that include plants and animals such as zooplankton; small animals, fish, and the immature stages of larger animals, along with phytoplankton; various forms of aquatic plant life such as Diatoms and Algae that have become trapped in sediment over millions of years (http://www.bbc.co.uk/schools/gcsebitesize/science/ocr_gateway_pre_2011/carbon_chem/4_crude_oil1.shtml). Crude oil/petroleum is not purely an oil or an inorganic chemical composition but comprised of multiple biochemical food groups needing an entire complement of enzymes, catalysts, emulsifiers, and metabolic support mechanisms to ensure degradation.

EcoBioClean® aligns with the science and chemistry of nature by stimulating nature's ability to reverse-engineer hydrocarbons for better metabolism. The components of crude oil (fossil fuel) are a source of energy, not only as fuel to power internal combustion engines, but also as food for microbes (https://www.energy.gov/science-innovation/energy-sources/fossil). Specific enzymes enable microbes to reduce the hydrocarbons at much lower temperatures than burning by breaking its chemical bonds. The energy released in these reactions is either stored in energy-rich compounds or used to drive energy-requiring reactions in the microbes. Biodegraded hydrocarbons do not accumulate on or inside cells thus preventing the contaminants from moving up the food chain (American Academy of Microbiology).

Microbes oxidize crude oil into simple carbon compounds which form the basic building blocks of new cell constituents. The formulation of EcoBioClean® also encourages horizontal gene transfer whereby oil-degrading enzymes can transfer copies of genes to other microbes, including microbes of different species previously incapable of degrading oil components (Douglas, 2010). Microbial organisms are known to respond in socially complex and cooperative ways when their environment is in a disruptive state (Crespi, 2001). Horizontal gene transfer is an important factor in the collaborative effort to maintain biochemical balance (Smith, 2001). Thus, bioremediation is taken to a new dimension, adding a bioconversion stage that is far more effective than leaving clean up to microbes alone. Without specific exogenous nutrients (in correct proportions), enzymes, proteins and co-factors the human body cannot survive. Similarly, this biological ecosystem needs total metabolic balance to perform at its peak on a continual basis–such is the environment of external ecosystems existing in nature. The chemistry of bodies of water and that of the human body are not significantly disparate.

2.2. Laboratory testing

The effectiveness of EcoBioClean® was tested under the U.S. EPA's standards as required for allowance of product use on the National Contingency Plan. Control and test flasks were prepared with simulated sea water (100 ml) to receive an approximately 5 ml volume of surface crude oil (oil slick). For the active test flask, the oil slick was dusted with EcoBioClean® formula (approx. 0.5 g) and the results compared visually and photographically with a control non-treated oil slick at timed intervals. For the shown experiments crude oil was provided by the U.S. EPA as Alaskan North Slope medium weight crude oil (AMS521). The EPA obtained samples from the National Environmental Technical Applications Center for Bioremediation Product Evaluation from the University of Pittsburgh Applied Research Center (Pittsburgh, PA).

During laboratory testing of this new GC/White bio-technology, crude oil was obtained from the U.S. Environmental Protection Agency (EPA) as Alaskan North Slope medium weight crude oil (NAS 521) National Environmental Technical Applications Center for Bioremediation Product Evaluation from the University of Pittsburgh Applied Research Center (Pittsburgh, PA). Analysis of the composition of the crude oil by gas chromatography-mass spectrometry (Gc-MS) is summarized in Table 1.

Analysis of the composition of the crude oil before and after testing was performed by gas chromatography-mass spectrometry (Gc-MS) using control and test samples taken over time. Analyses were run by Covance Laboratories (FDA/GLP Regulations, 2004)

3. Results and discussion

Figs. 1 and 2 show the effect of EcoBioClean® on the oil slick in a

Table 1
North Alaskan crude chemical composition.

Alkane/cycloalkane hydrocarbons	Amount (μ/g)	Polycyclic aromatic hydrocarbons	Amount (μ/g)
C10	4.33	nap	1.00
C11	2.67	C1-nap	9.67
C12	2.00	C2-nap	595.00
C13	5.67	C3-nap	3124.67
C14	268.67	C4-nap	2669.33
C15	2511.67	phe	430.00
C16	3977.67	C1-phe	1295.33
C17	4377.00	C2-phe	1767.00
pristane	2817.33	C3-phe	1481.33
C18	4264.00	C4-phe	699.33
phytane	2468.00	flu	112.33
C19	4021.00	C1-flu	476.00
C20	3614.00	C2-flu	675.33
C21	3075.00	C3-flu	785.00
C22	3372.67	dbt	372.33
C23	3189.00	C1-dbt	760.00
C24	3009.67	C2-dbt	931.33
C25	2920.00	C3-dbt	838.33
C26	2699.67	nbt	72.67
C27	1994.00	C1-nbt	269.67
C28	3333.00	C2-nbt	361.67
C29	1485.00	C3-nbt	305.67
C30	1051.33	flt	4.00
C31	891.67	pyr	18.67
C32	701.00	C1-pyr	150.33
C33	640.67	C2-pyr	0.00
C34	769.67	cry	95.00
C35	901.00	C1-cry	194.67
		C2-cry	256.33
		C3-cry	182.33
		C4-cry	197.67
Total alkanes	58,367.33	Total aromatics	19,132.00

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