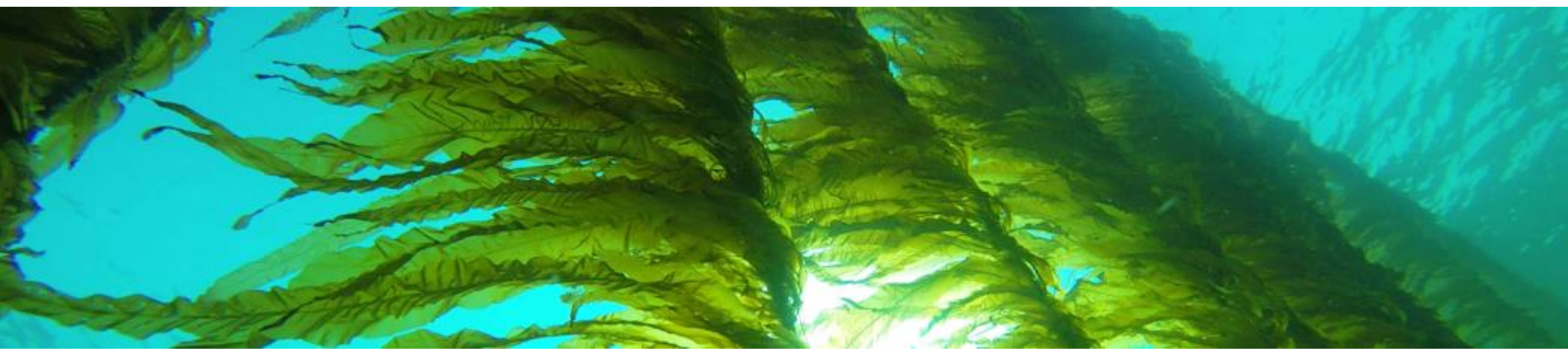
SEAWEED ENERGY SOLUTIONS AS

From fuels to food… and back again
– a case study of seaweed biomass

ERA MBT Final Conference
20th November 2017
Jon Funderud



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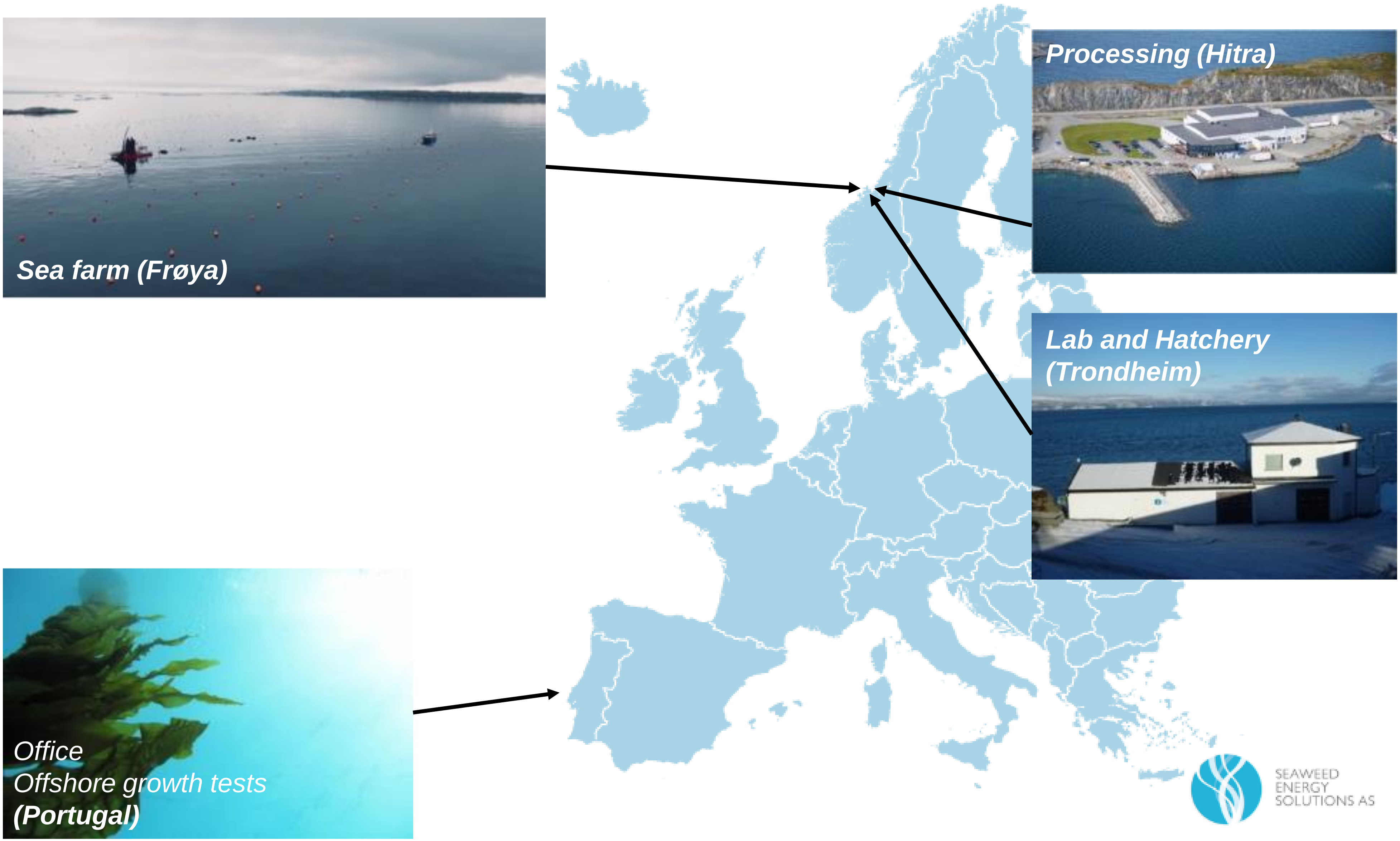

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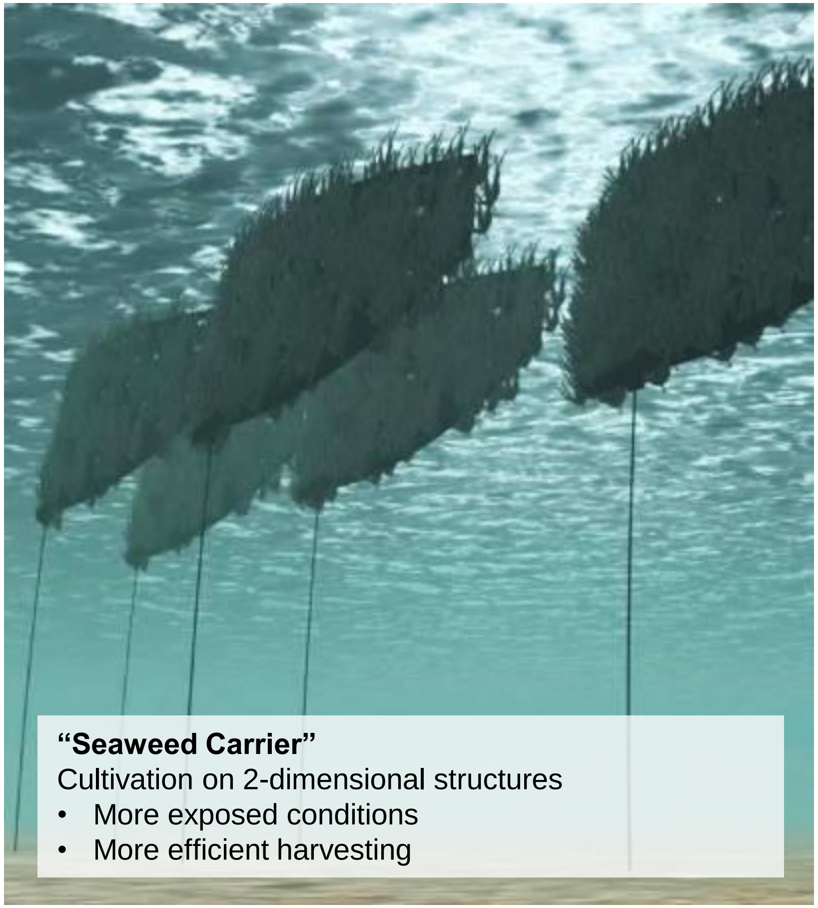
Technology development for energy scale seaweed farming



"Seaweed Carrier"
Cultivation on 2-dimensional structures
- More exposed conditions
- More efficient harvesting

The Research Council of Norway · eurostars™ · SINTEF · NTNU Norwegian University of Science and Technology · ciimar · Stolt Sea Farm · aqualine Strength counts · Statoil

Seaweed farm Frøya, Norway

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Innovation Norway

Processing for food

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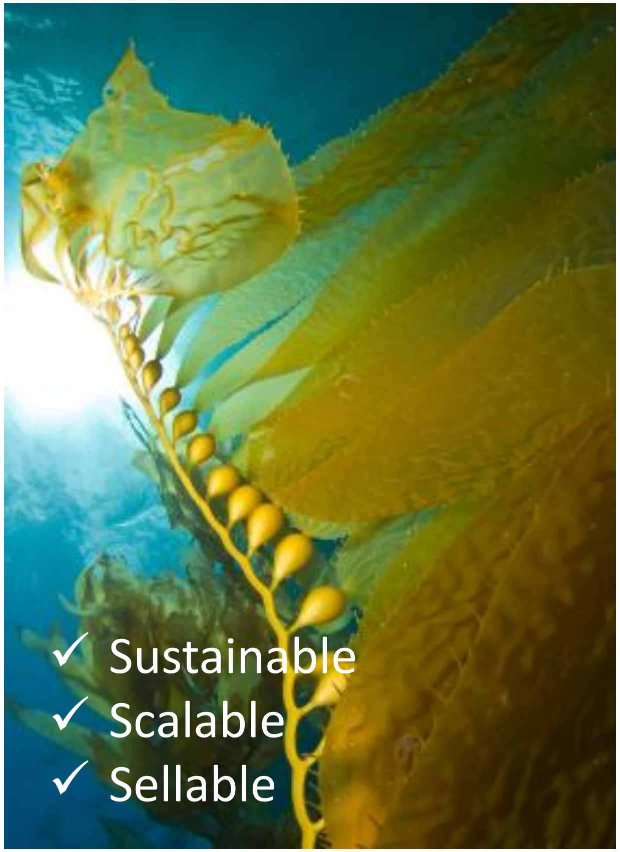
SES Seaweed Food Workshop
April 2016

Seaweed for food
A rapidly growing market in Europe

Why seaweed biomass?

- Primary biomass (photosynthesis)
- High productivity
- Suitable for offshore farming
- No feed, fertilizer, freshwater or land area
- Many environmental benefits:
  - Increase biodiversity (habitat provision and food supply)
  - Uptake of CO_2 and nutrients
- Exciting biomass with broad range of product opportunities



Large scale seaweed farming is not an opportunity ...it's **reality** (and 10x bigger than salmon)

Global market (>20 million ton)

Food
- Salads, soups, pestos, herbs
- Snacks
- Salt replacement
- Flavour
- Texturizer

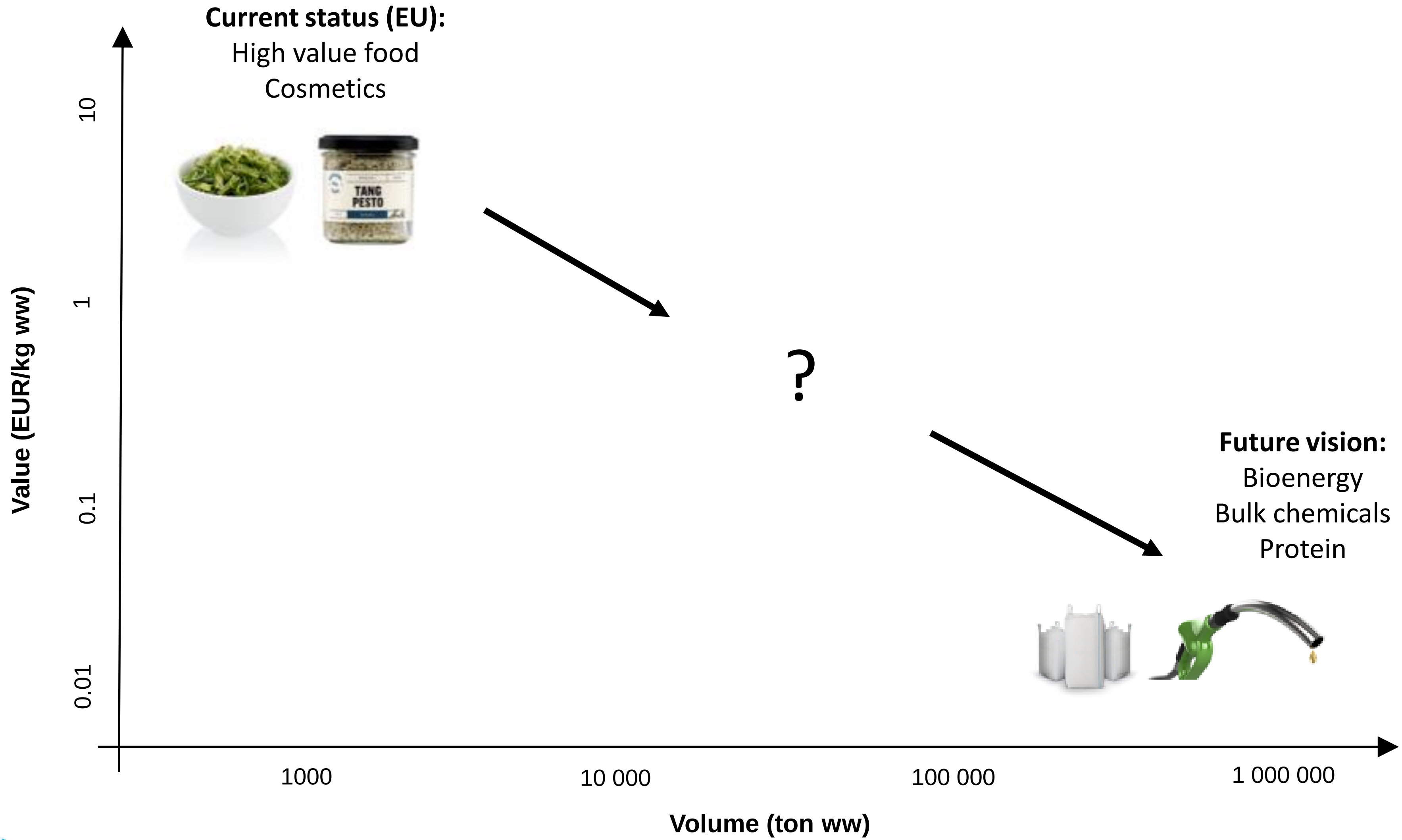
Health & nutrition (humans and animals)
- Gut health (fibers, prebiotics)
- Immune stimulation
- Anti-oxidants
- Anti-inflammatory
- Anti-biotic
- Protein
- Vitamins
- Minerals
- Fatty acids
- Skin health (cosmetics)
- Animal fur and mucus health
- Pharmaceuticals/bioactives

Plant health & nutrition
- Growth promoters/biostimulants
- Plant defense
- Macronutrients (N, P, K)
- Micronutrients (Fe, Ca, Cu)
- Trace elements

Specialty chemicals
- Alginate, carrageenan, agar
- Alginate derivatives
- Mannitol and derivatives
- Bioplastics, fiber, textiles
- Minerals

Industrial commodities
- Biofuels, biogas
- Biochemicals
- Protein

“Market roadmap” for seaweed farming in Europe



SEAWEED ENERGY SOLUTIONS AS

New markets coming?

New markets coming?

MIT Technology Review

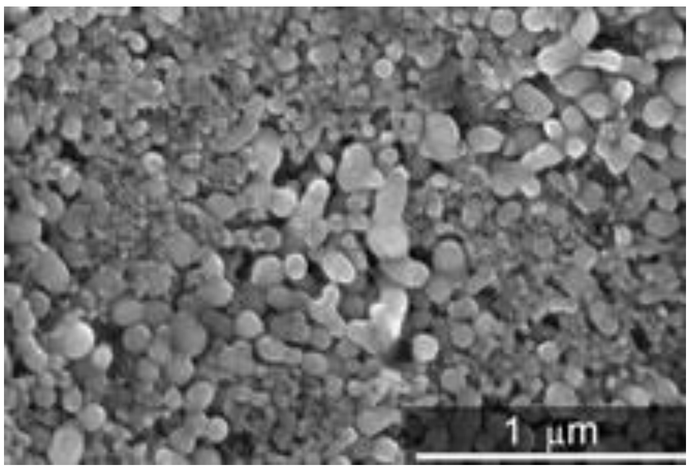
Sustainable Energy

Battery Storage Could Get a Huge Boost from Seaweed

A binding agent found in everything from ice cream to cosmetics could let lithium-ion cells hold much more energy.

by Stephen Cass September 8, 2011

Lithium-ion batteries could hold up to 10 times as much energy per cell if silicon anodes were used instead of graphite ones. But manufacturers don't use silicon because such anodes degrade quickly as the battery is charged and discharged.



Battery pack: These silicon particles were coated with a binder derived from giant kelp. The binder's ability to allow the particles to swell without cracking could allow silicon to be used in lithium-ion battery anodes.

Researchers at the Georgia Institute of Technology and Clemson University think they might have found the ingredient that will make silicon anodes work—a common binding agent and food additive derived from algae and

ACS central science

Research Article

http://pubs.acs.org/journal/acscii

Egg-Box Structure in Cobalt Alginate: A New Approach to Multifunctional Hierarchical Mesoporous N-Doped Carbon Nanofibers for Efficient Catalysis and Energy Storage

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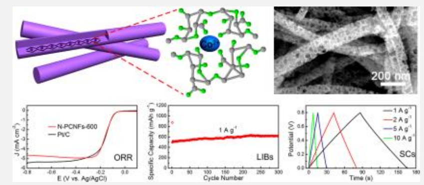
Supporting Information



ABSTRACT: Carbon nanomaterials with both doped heteroatom and porous structure represent a new class of carbon nanostructures for boosting electrochemical application, particularly sustainable electrochemical energy conversion and storage applications. We herein demonstrate a unique large-scale sustainable biomass conversion strategy for the synthesis of earth-abundant multifunctional carbon nanomaterials with well-defined doped heteroatom level and multimodal pores through pyrolyzing electrospinning renewable natural alginate. The key part for our chemical synthesis is that we found that the egg-box structure in cobalt alginate nanofiber can offer new opportunity to create large mesopores (~10–40 nm) on the surface of nitrogen-doped carbon nanofibers. The as-prepared hierarchical carbon nanofibers with three-dimensional pathway for electron and ion transport are conceptually new as high-performance multifunctional electrochemical materials for boosting the performance of oxygen reduction reaction (ORR), lithium ion batteries (LIBs), and supercapacitors (SCs). In particular, they show amazingly the same ORR activity as commercial Pt/C catalyst and much better long-term stability and methanol tolerance for ORR than Pt/C via a four-electron pathway in alkaline electrolyte. They also exhibit a large reversible capacity of 625 mAh g^{-1} at 1 A g^{-1}, good rate capability, and excellent cycling performance for LIBs, making them among the best in all the reported carbon nanomaterials. They also represent highly efficient carbon nanomaterials for SCs with excellent capacitive behavior of 197 F g^{-1} at 1 A g^{-1} and superior stability. The present work highlights the importance of biomass-derived multifunctional mesoporous carbon nanomaterials in enhancing electrochemical catalysis and energy storage.

INTRODUCTION

As a dominant electrochemical material, carbonaceous materials have been extensively applied in energy conversion and storage applications such as proton exchange membrane fuel cells, rechargeable lithium ion batteries (LIBs), and supercapacitors (SCs) because of their low cost, outstanding cycle stability, and wide-ranging operating voltage (0–3 V).[1−5] However, the traditional carbon materials cannot satisfy the ever-increasing need for high-performance energy conversion and storage applications due to their low catalytic activity, theoretical capacity (only 372 mAh g^{-1}), and energy density (1–10 Wh kg^{-1}).[6] To improve the electrochemical performance of carbon materials without the decline of power delivery and cycle life, the most efficient strategy is to design new types of carbon nanostructures. One-dimensional (1D) carbon nanomaterials including carbon nanotubes and carbon nanofibers have been explored to replace the traditional carbon materials for energy conversion and storage applications due to their salient features (high surface area and good electrical conductivity).[7,8] In

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New markets coming?

Seaweed bioethanol?
Yes, we can!

THANK YOU!