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Ultra High Durability Concrete

Rethinking coastal defence and Green-energy Service infrastructures through enHancEd-durAbiLity high-performance cement-based materials

ANF DEVELOPMENT

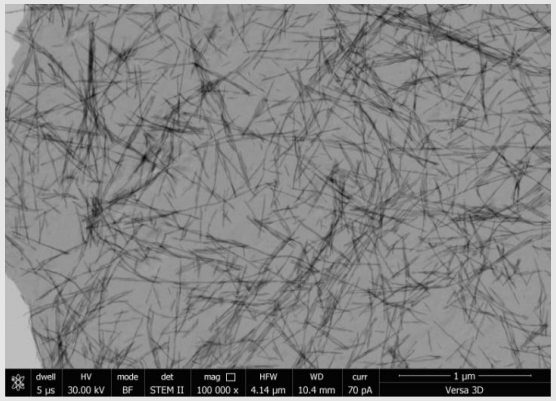
NAFEN
Enhancing the world with nano

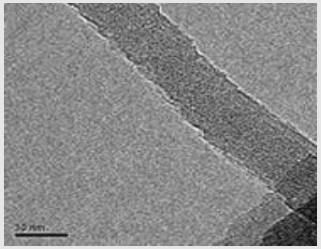
Denis Lizunov, PhD - Chief of Technical Support and Development

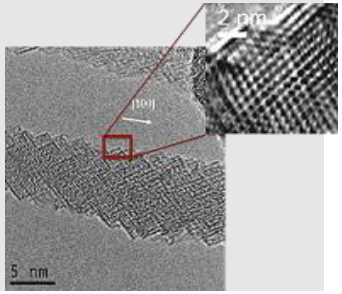
Aleksei Tretjakov, PhD - Project Coordinator

January 10th, 2018

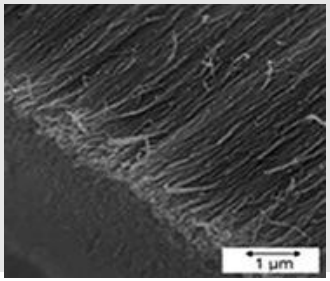
NAFEN – producer of Nafen™ alumina nanofibers

- Pure Al_2O_3 (gamma phase)
- Diameter 7 nm (controllable parameter)
- Length of whisker – 300-350 nm
- Thermo stability till 1100 C (after transition to alpha phase)
- Facet surface
- 





- Pre-dispersed structure (nano forest)
- One direction orientation of fibers
- Interfiber distance 20-50 nm (controlled parameter)
- Non agglomerated after dispersion
- Surface area - 155 m2/g



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NAFEN structure

ANF Locations

Main location (R&D, laboratory and production facility)

- ANF Development OÜ, Tööstuse 48a, 10416 Tallinn, Estonia

Other locations:

- ANF Technology Ltd., London, UK
- Representative office, Sacramento, USA

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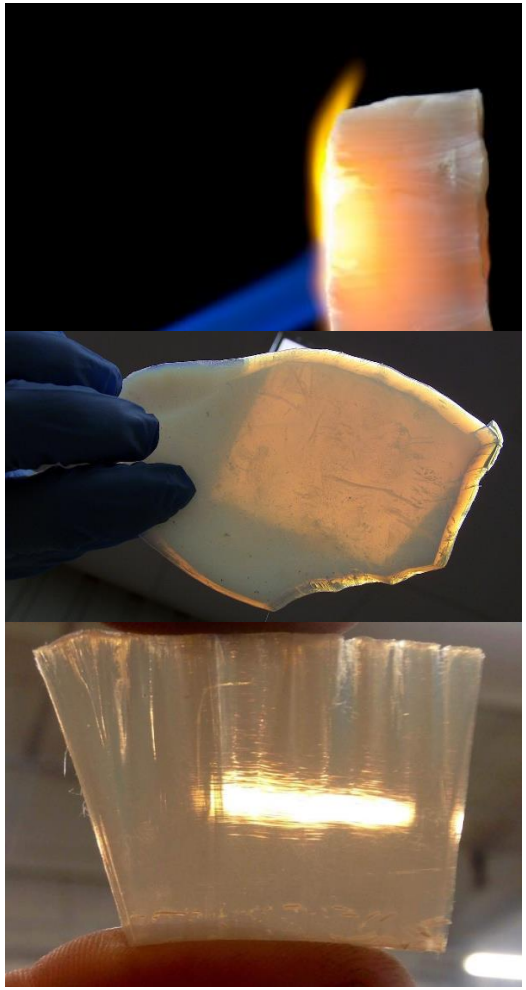
Team – R&D Department

Persons involved in the project

- 18 employees involved in the Nafen synthesis and dispersions production
- internal expertise - ANF employs 4 PhDs in addition to other technical experts
- outsourced expertise - research institutes
- key personnel -

Chief of Technical Support and Development – Denis Lizunov, PhD
Project Coordinator – Aleksei Tretjakov, PhD
Head of Production – Sergei Kniga, PhD
Main Technologist – Alexey Kirillov, PhD
Financial Director – Vladimir Jeletski, MSc



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Overview

2010

Birth of a new nano-material

New crystalline nano material was born on the surface of liquid metal

2011-2012

First industrially available alumina nanofibers

The material had the potential to make substantial improvements in many markets, but can it be produced industrially? Can it be reproduced at all?

2013

First real nano composites for global markets of $500 bln.

While seeking the best market application, we created world's first true polymer nano composite

2014-2017

Industrial scale production of nanofibers

Serial production is being set up and nanofibers are going commercial

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IP Portfolio: Combination of the Core Synthesis and Various Applications Technologies

PCT Application for The Core Synthesis Technology

- US20130192517 A1 / PCT/IB2013/000120 «Method And System For Alumina Nanofibers Synthesis From Molten Aluminum», ANF Technology Limited, 01.08.2013

Patents Applications and Patent Applications

- 13/783,297 «Apparatus And Method For Producing Coatings Reinforced With Alumina Nanofibers», ANF Technology Limited, 03.03.2013, 01.02.2014 (patent granted)
- 13/783,295 «Nanocomposite Material Containing Alumina Nanofibers And Method For Making Same», ANF Technology Limited, 02.03.2013, 01.02.2014 (patent granted)
- 13/952,661 «Method And Apparatus For Producing A Nanocomposite Material Reinforced By Unidirectionally Oriented Pre-dispersed Alumina Nanofiber»
- «Method And Apparatus For Producing Fiber-reinforced Polymers Additionally Reinforced By Alumina Nanofibers»
- «Alumina Nanofiber Reinforced Cement-based Materials And Method For Producing Same»

Nafen™ Trademark Protection

- NAFEN brand is protected in 3 classes in major markets

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Grants & Research Projects Portfolio:

Participation in The EU Framework Programme For Research And Innovation HORIZON 2020

- "Nano-particle based enhancement of composite and thermoplastic materials" 08.2015-01.2017, €2,5mln - **685213 Nafen**

  Objectives: (1) setting up a solid footprint within the groups of European thermoplastics and thermosets manufacturers and thus (2) enhancing many end products.

- **ReSHEAlience**

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ANF Certification - Development And Production Of Nafen™ Fibers

REACH - European Community Regulation on Chemicals and Their Safe Use (EC 1907/2006)

- ANF has the REACH full registration (Letter of Access from the Aluminium REACH Consortium)

ANF Certification Records

- ISO 9001:2015 Quality management system
- ISO 14001:2015 Environmental management system
- OHSAS 18001:2007 Health and safety management system

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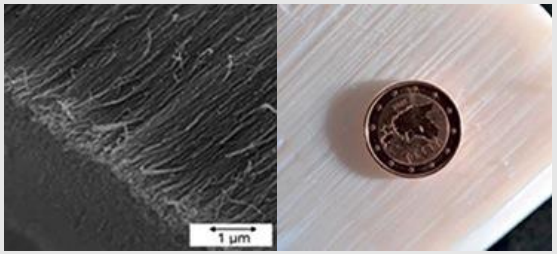
Nafen™ Solutions

Nafen™ Nanofibers

- ✓ Easy to use in different systems
- ✓ Surface functionalization according to the clients' needs
- ✓ Scalable production



Nafen™ Dispersions in Base Materials

- ✓ Possibility to disperse in various media
- ✓ Non hazardous: safe use as dispersant in polymeric, solvent or water based system
- ✓ Improvement of the different physical and mechanical properties of the end-product

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Nafen™ Nanofibers

The Main Fields of Application

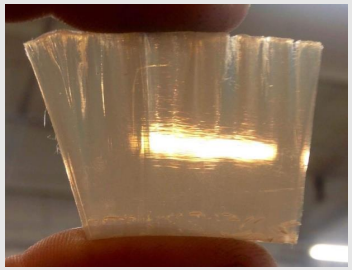
Enhancemet of
- Polymers
- Ceramics
- Composite materials
- Metal matrix composites
- Concrete

Prospective directions
- Carrier for catalysts
- Catalyst in specific reactions
- Sorbent agent
- Reinforcing filler
- Fireproof material

Also potential use in
- Fine abrasion materials
- Dielectric materials
- Lightweight and 3D printing applications

Nanofibers Surface Can Be Functionalized By

- Silane, silazane, titanates, phosphonates
- Graft-polymerization, encapsulation, etc.
- Nitriding, alkylation, organometallic compounds
- Inorganic substances (graphene, metals, etc.)



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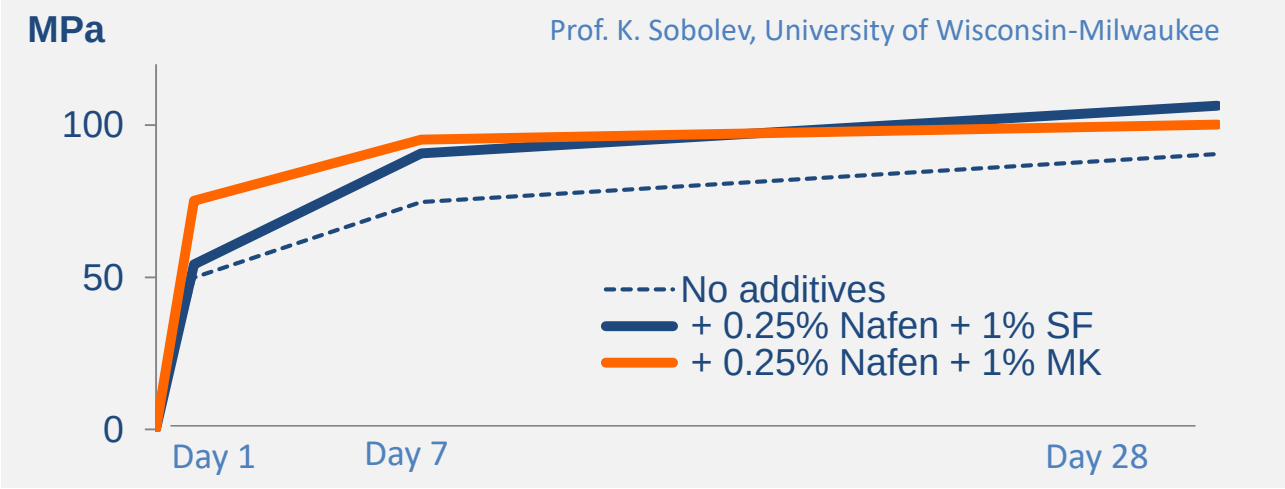
Nafen™ Dispersed in Cement Mixture Radically Improves Rate of Strength Gain

Holcim Type I portland cement Water/cement ratio: 0.27	Compression strength, MPa		
	Day 1	Day 7	Day 28
No additives	49.9	74.7	90.5
+ 0.25% Nafen* + 1% SF**	54.2	90.7	106.4
+ 0.25% Nafen* + 1% MK**	75.2 (+50%)	95.3 (+30%)	100.2 (+11%)

* 0.25% – to cement mix mass

** SF – micro silica, MK – metakaolin, typical additives to cement. Do not improve strength at 1% loading.



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NAFEN participation in the project

- Utilise the existing NAFEN nanofibers production facility with the capacity of 20 tons / year for providing NAFEN dispersions for cooperation and UHDC co-development with the project partners
- Improve the effectiveness of production systems for NAFEN nanofibers according to the Concrete Market demands (WP4)
- Improve the existing products (various NAFEN dispersions) to enhance durability properties of concrete to resist XS and XA conditions (WP4)
- Allow testing of the modified products in cooperation with the project partners
- Develop the industrial technology for Nafen™ introduction into UHDC and provide recommendations on using of Nafen dispersion in formulation of mixing design guidelines for achieving and functionalization of UHDC.

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NAFEN ambition

NAFEN will optimize processes/equipment for high volume alumina nanofibers production for UHDC, and will get into pre-commercial stage targeting to a 30% market increase, entering the concrete production/construction sector. The company will scale-up its production capabilities to cope with large scale applications. Its expected plant production capacity is 300 ton/year of NAFEN™ nanofiber dispersion.

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Strategy to reach the objectives

WP4 - Task 4.1: Improvement in concrete constituents to enhance its durability
Leader - NAFEN, Partners: NAFEN, API, Penetron Timing M1-M9

Functionalization effectiveness and improvement of production efficiency of alumina nano-fibres (NAFEN), crystalline admixtures (Penetron) and nanocellulose (API):

- improving physical/geometrical parameters of the products, e.g. to provide particle size (Penetron) or nanofibers diameters (NAFEN) in a “grading” form;
- acting of the surface defect structure and on the active groups on the surface (nature, number) to improve the reactivity of alumina nanofibers (NAFEN);
- improvement on the dispersion process: ultra-sonication at the factory and supply in liquid form or in the form of a ***self-dispersing powder (NAFEN, API);***
- verification of the compatibility with other mix constituents (NAFEN, API, Penetron);
- scalability to production needs for concrete applications and use in pilot demonstration (WP7, WP8)

NAFEN also involved in WP5, WP7, WP8, WP9 – support for partners

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Deliverables

D 4.1- Recommendation on the use of crystalline admixtures, nanofibers and nano-cellulose for production of UHDC (M9) - NAFEN

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