



## SCIENCE AND TECHNOLOGY

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### ASPHALT SHINGLE AND SBS MEMBRANE ROOFS

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AN INTRODUCTION

# Nanosilica modified asphalt

## A decade of science

Although GoNano is the first and currently only North American company offering a nanotechnology solution to enhance, protect and increase lifespan of asphalt shingle roofs, the science of nanosilica modified asphalt pavements spans a decade back and benefits from hundreds of scientific studies and testing.

## Scientific evidence

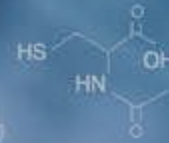
Major scientific institutes have been studying and testing the integration of nanosilica on asphalt pavements with important scientific evidence.

## Durability

The scientific literature forms near consensus: nanosilica solutions modify and enhance asphalt properties, therefore significantly increasing anti-aging performance and durability.

## Life-cycle costs

Nanosilica solutions represent therefore an important technological innovation bearing the potential of reducing the life-cycle costs of asphalt roads and, now, of asphalt shingle roofs with GoNano's innovative and exclusive nanosilica solution.



# Nanosilica modified asphalt

## Evaluation of Asphalt Binders Modified with Nanoclay and Nanosilica <sup>1</sup>

"During last decade, researchers' interest in nanotechnology applications, particularly in the field of pavement materials, has been increasing. (...) Finally, the Dynamic Shear Rheometer (DSR) results showed obvious improvement in the performance grade leading to higher resistance to permanent deformation."

## Effect of nanosilica particles on polypropylene polymer modified asphalt mixture performance <sup>2</sup>

"The asphalt performance tests flexural four point beam fatigue test, indirect tensile strength, indirect tensile stiffness modulus (...) This indicates that nanosilica particles have significant effect on improving the performance properties of polymer modified binders. Also, the result reveals that thermoplastic polymer polypropylene with nanosilica particles when used as bitumen modifiers improve the performance and durability of asphalt mixtures"

## The fatigue behavior of SBS/nanosilica composite modified asphalt binder and mixture <sup>3</sup>

"The results showed that the fatigue life of asphalt binder and asphalt mixture were increased significantly by adding SBS/nanosilica nanocomposite"

## Analysis of interfacial adhesion properties of nano-silica modified asphalt mixtures using molecular dynamics simulation <sup>4</sup>

"The results show that oxidation aging promotes the asphaltene aggregate on the surface of the silica aggregate, while the effect of nano-silica is reversed. (...) The presence of nano-silica reduces the susceptibility of asphalt mixture to water damage or sodium chloride solution erosion."

## Rheological investigation of asphalt binder modified with nanosilica <sup>5</sup>

"The addition of nanosilica enhanced the rutting potential of the asphalt binder. Fatigue evaluation using Linear Amplitude Sweep test showed that incorporation of nanosilica arrests the micro crack nucleation and therefore enhanced the fatigue performance of asphalt binder. (...)."

## Laboratory evaluation of composed modified asphalt binder and mixture containing nano-silica/rock asphalt/SBS <sup>6</sup>

"Comparing these tests results with the properties of unmodified asphalt mixture, nano-silica and rock asphalt cause an improvement in pavement performance. nano-silica/rock asphalt/SBS modified asphalt mixture had higher temperature stability, low-temperature cracking resistance, moisture susceptibility and durability than 5% SBS modified asphalt except the similar fatigue life. Furthermore, economic analysis indicated that the nano-silica/rock asphalt/SBS modified asphalt mixture had higher cost effectiveness."

## Performance evaluation of nanosilica-modified asphalt binder <sup>7</sup>

"It was found that adding nanosilica to asphalt binder improves its rutting resistance. Results of all the rheological approaches showed that resistance to permanent deformation increases with the addition of nanosilica. Nanosilica-modified binders have high resistance to oxidative ageing."



A BRIEF REVIEW OF THE LITERATURE

# Nanosilica modified asphalt



" An additional laboratory study was conducted to characterize the performance properties of the corresponding asphalt mixtures based on the resilient modulus, indirect tensile strength, fracture energy, moisture susceptibility, and fatigue life. Overall, the addition of NS material has a positive influence on different properties of the asphalt binder and mixture and can be used to construct durable pavements, thereby reduce the life-cycle costs of the pavement." <sup>9</sup>



"To cope with such demand, the use of nanomaterials for the asphalt binder modification seems promising, as with a small amount of modification an important enhancement of the asphalt mixture mechanical performance can be attained. Generally, the effects (...) such as, permanent deformation, stiffness modulus, fatigue resistance, indirect tensile strength, and Marshall stability. " <sup>10</sup>



"(...) that the antiaging property and rutting and fatigue cracking performance of nanosilica modified asphalt binders are enhanced (...)" <sup>8</sup>

## REFERENCES

# Nanosilica modified asphalt

<sup>1</sup> Helal Ezzat, Sherif El-Badawy, Alaa Gabr, El-Saaid Ibrahim Zaki, Tamer Breakah, Evaluation of Asphalt Binders Modified with Nanoclay and Nanosilica, *Procedia Engineering*, Volume 143, 2016, Pages 1260-1267, ISSN 1877-7058.

<https://doi.org/10.1016/j.proeng.2016.06.119>

<sup>2</sup> Nura Bala, Madzlan Napihah, Ibrahim Kamaruddin, Effect of nanosilica particles on polypropylene polymer modified asphalt mixture performance, *Case Studies in Construction Materials*, Volume 8, 2018, Pages 447-454, ISSN 2214-5095.

<https://doi.org/10.1016/j.cscm.2018.03.011>

<sup>3</sup> Gholamali Shafabakhsh, Mobin Rajabi, Ali sahaf, The fatigue behavior of SBS/ nanosilica composite modified asphalt binder and mixture, *Construction and Building Materials*, Volume 229, 2019, 116796, ISSN 0950-0618.

<https://doi.org/10.1016/j.conbuildmat.2019.116796>

<sup>4</sup> Zhengwu Long, Lingyun You, Xianqiong Tang, Wenbo Ma, Yanhuai Ding, Fu Xu, Analysis of interfacial adhesion properties of nano-silica modified asphalt mixtures using molecular dynamics simulation, *Construction and Building Materials*, Volume 255, 2020, 119354, ISSN 0950-0618.

<https://doi.org/10.1016/j.conbuildmat.2020.119354>

<sup>5</sup> Rheological investigation of asphalt binder modified with nanosilica: Bhat, F.S., Mir, M.S. Rheological investigation of asphalt binder modified with nanosilica. *Int. J. Pavement Res. Technol.* 14, 276–287 (2021).

<https://doi.org/10.1007/s42947-020-0327-2>

<sup>6</sup> Liangcai Cai, Xingang Shi, Jing Xue, Laboratory evaluation of composed modified asphalt binder and mixture containing nano-silica/rock asphalt/SBS, *Construction and Building Materials*, Volume 172, 2018, Pages 204-211, ISSN 0950-0618. <https://doi.org/10.1016/j.conbuildmat.2018.03.187>

<sup>7</sup> Bhat, F.S., Mir, M.S. Performance evaluation of nanosilica-modified asphalt binder. *Innov. Infrastruct. Solut.* 4, 63 (2019).

<https://doi.org/10.1007/s41062-019-0249-5>

<sup>8</sup> David Wingard, Ph.D., M.ASCE Research Assistant Professor, Dept. of Civil Engineering, Clemson Univ., Clemson, SC

<sup>9</sup> Mahmoud Enieba, Aboelkasim Diabb, Department of Civil Engineering, Assiut University, 71516, Egypt

<sup>10</sup> João Crucho CERIS, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-001 Lisboa, Portugal



# The science is clear

**Nanosilica is shown throughout a decade of scientific research and testing to modify mechanical properties of asphalt, which correspond to aging factors.**

By enhancing durably the different aging factors (flexibility, hydrophoby, anti-aging performance), nanosilica significantly increases overall lifespan of asphalt.

| Mechanical properties                                                   | Aging factors          |
|-------------------------------------------------------------------------|------------------------|
| Resilient modulus<br>Indirect tensile strength<br>Fracture energy point | Flexibility            |
| Moisture susceptibility                                                 | Hydrophoby             |
| Oxydation                                                               | Anti-aging performance |

SCIENCE STUDY

# Independent scientific study

GoNano conducted an independent scientific study in Canada with the CNETE on both asphalt shingles and SBS membranes.

Conclusions: with one treatment, GoNano adds 10 to 15 years of additional lifespan to an asphalt shingle roof, or an SBS membrane roof, depending on its age (roofs must be 0-12 years of age; the younger the shingles, the more lifespan generated).

## National Center in Environmental Technology and Electrochemistry

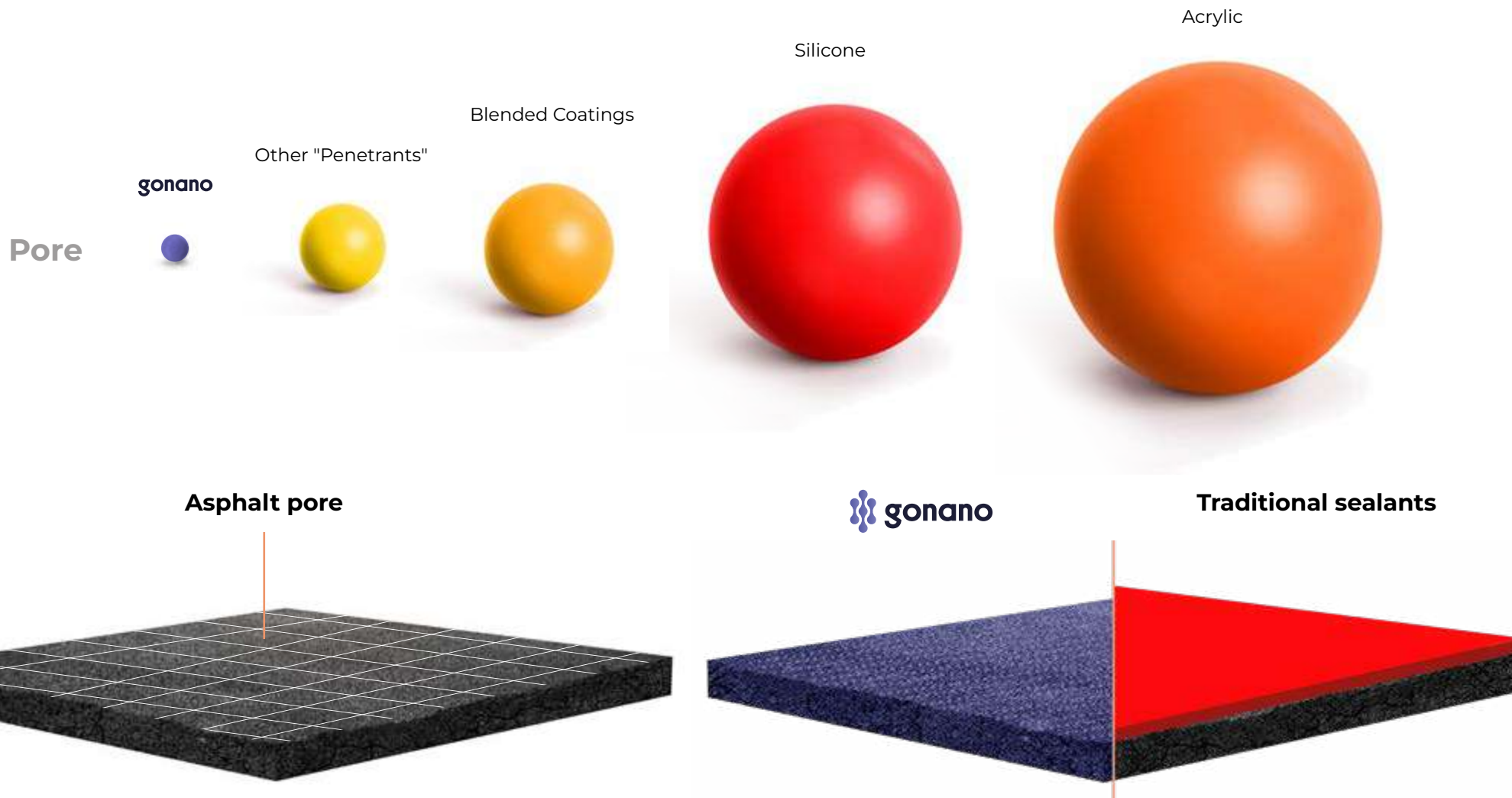


**Antonio Avalos Ramirez - Ph.D., Ing.**  
**Environmental Technology Researcher**

*"Asphalt shingle samples treated with the technology commercialized by GoNano demonstrated several improvements over untreated samples, including a significant improvement on anti-aging properties and durability."*

GONANO PARTICLES

# GoNano **vs** traditional sealants



GONANO EVOLUTION

# Permanent structure modification

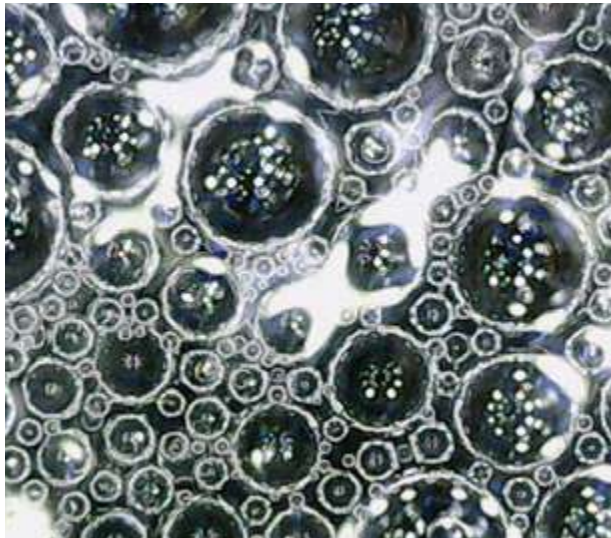
GoNano's technology doesn't add a protective layer, like traditional sealants, nor does it simply replace lost oil: it modifies and enhances the molecular structure of asphalt shingles permanently.

**Before**



Regular shingle

**During**



A modification reaction takes place  
everywhere in the shingle

**After**

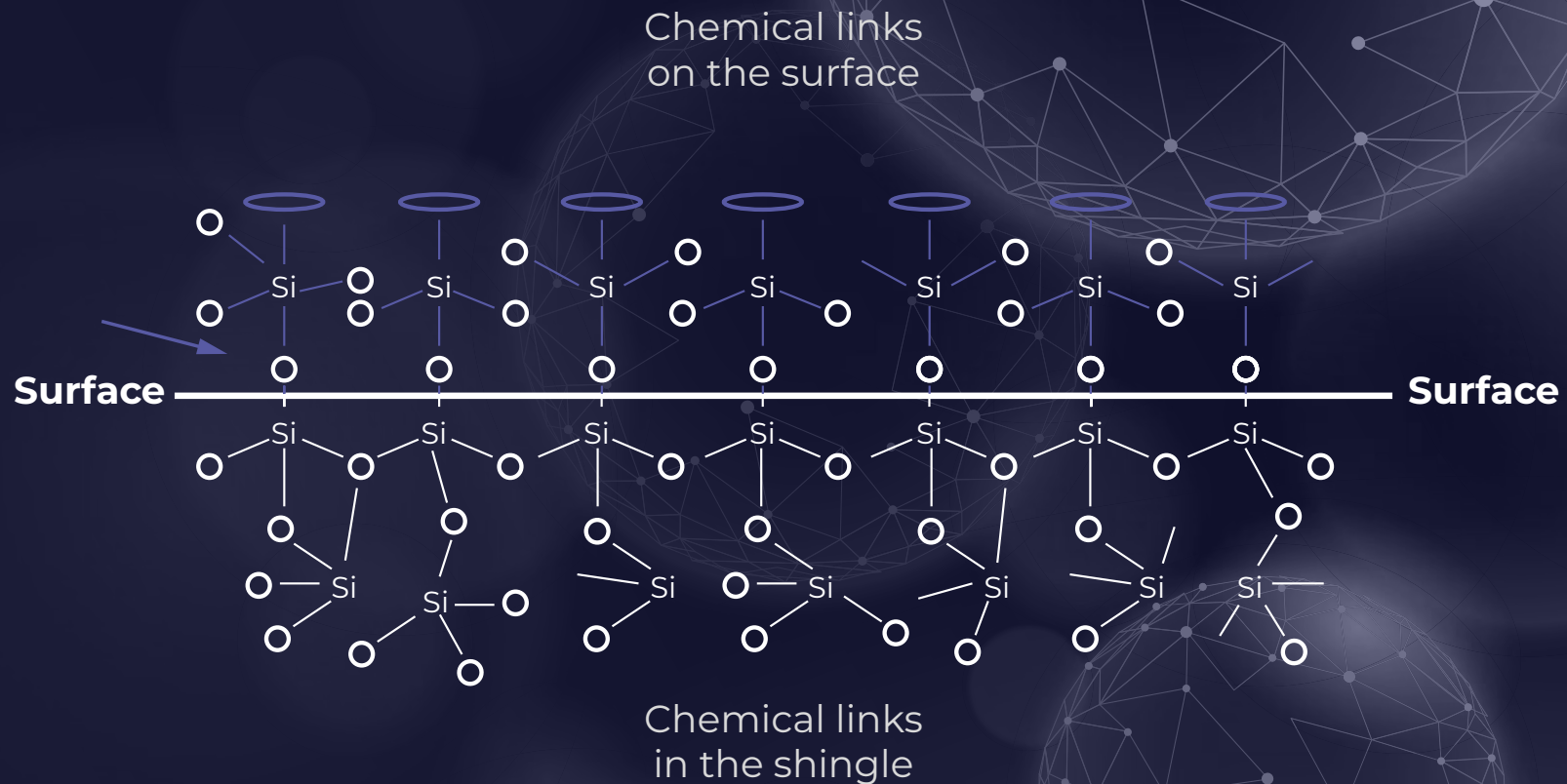


GoNano modified shingle

GONANO EFFECT

# Permanent structure modification

GoNano's technology fuses at the molecular level with the organic and inorganic material of the shingle, creating new chemical bonds (Si particles) linking the different elements of the shingle together. This chemical bonding permanently changes the molecular structure of the asphalt shingle from the inside out.



# Technological impacts

| New properties          | Advantages                                        |
|-------------------------|---------------------------------------------------|
| Flexibility             | Increased resistance to hailstorms and High Winds |
| Hydrophobic             | Cleans and prevents algae                         |
| Increased resistance to | Reduces/prevents water infiltration               |
| Heat                    | Preserves and regenerates original colour         |
| Oxydation               | Stops loss of granules                            |
| UV                      | More effective evacuation of ice and snow         |
| Anti Moisture           |                                                   |

GONANO CLASS

# Class 1 Shingle vs Class 4 Shingle



## Class 1

1. No impact resistance
2. High loss of granules
3. Lifespan: 12 to 15 years
4. Cost: \$5-6 a S/F



## Class 4

1. Highest impact resistance
2. Low loss of granules
3. Lifespan: 22-25 years
4. Cost: \$9-10 a S/F

### IMPACT RESISTANCE TESTING

| Hail size (in.) | 1 1/4"                                                                                | 1 1/2"                                                                                | 1 3/4"                                                                                | 2"                                                                                    |
|-----------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
|                 |  |  |  |  |
| Class           | 1                                                                                     | 2                                                                                     | 3                                                                                     | 4                                                                                     |

# Hailstorm resistance

## Only company

GoNano is the first and only North American company to have tested its residential roof protection technology with a major standards organization.

## Official impact resistance standard

GoNano's shingle nanotechnology was tested under the official North American impact resistance standard used by standards organizations for both shingle manufacturers and insurance companies.

## Conclusions of the test

- #1. GoNano transforms Class 1 shingles into Class 3, with one treatment
- #2. GoNano transforms Class 1 shingles into Class 4, with two treatments

## Shingle Class transformation

GoNano not only adds 10 to 15 years of additional lifespan to an asphalt shingle roof, it also transforms common Class 1 roofs into the highest hail resistance Classes (3 and 4).

## Durability

It is scientifically established that, through enhancing aging factors of asphalt durably (flexibility being one of them), the impact resistance Class transformation generated by GoNano is durable and long lasting (for the scientific evidence, see Slide 6).

## A fraction of the cost

GoNano's technology represents a major technological innovation that transforms current and common Class 1 roofs into hailstorm resistant roofs (Classes 3 and 4), though only at a marginal fraction of the cost of hailstorm resistant shingles themselves (Classes 3 and 4).

## Residential insurance cost reduction

GoNano reduces substantially risks of hailstorm damages, helps mitigate climate change's increasing impacts on home insurance costs, and help both homeowners and insurance companies significantly reduce one of the biggest insurance weather expenses.

## Climate change

According to the Institute for Catastrophic Loss Reduction's latest report,

*"Climate change will worsen future hailstorms, making impact-resistant shingles more valuable and the yellow area bigger".*<sup>1</sup>

<sup>1</sup>Reference: <https://www.iclr.org/wp-content/uploads/2022/04/Benefit-cost-analysis-of-Impact-resistant-asphalt-shingle-roofing2.pdf>



# Environment and human health



LES PRODUITS GO NANO INC.  
Material Safety Data Sheet

MSDS No:1003  
Version: 1.3

Page: 5/6  
Date: 2020/04/16

6965 GONANO WATER PROOF AGENT

## 12. ECOLOGICAL INFORMATION

### 12.1 Environmental effects

Acute effects: No harm to aquatic organisms.

Chronic effects: No harm to aquatic organisms.

### 12.2 Biodegradation: Quickly biodegradable.

### 12.3 Bioaccumulation : No bioaccumulation potential.

**GoNano's technology has been categorized in accordance with the Occupational Safety and Health Administration standards (OHSa) as being.**

1. "Quickly biodegradable"
2. "No bioaccumulation potential"
3. "No harm to aquatic organisms"

GoNano is therefore safe for the environment and on human health.

GONANO

# Conclusions

## **Additional lifespan**

With one treatment, GoNano adds 10 to 15 years of additional lifespan to an asphalt shingle roof or an SBS membrane roof.

## **Shingle Class transformation**

GoNano transforms common Class 1 shingle roofs to the highest hailstorm resistant shingles (Classes 3 and 4).

## **Insurance markets costs reduction**

GoNano necessarily reduces insurance costs for the market as a whole, i.e. for homeowners and insurance companies. The only remaining question is: by how much (will be the object of a mid and long term statistical study conducted in partnership with insurance companies).

## **Water infiltration risks reduction**

It is also expected that, through the hydrophobic property, GoNano reduces risks of water infiltration and its associated insurance costs.

## **The challenge of climate change**

GoNano technology is a major opportunity to reduce risks of hailstorm damages, and therefore insurance costs, while helping and preparing the residential sector to mitigate the increasing destructive power of climate change.

## **Human health and ecology**

GoNano is safe for both the environment and human health



GONANO

# To go further

## To go further: pressures of climate change on the insurance industry

### How climate change is leading to bigger hailstones:

<https://www.bbc.com/future/article/20220314-how-big-can-hailstones-grow#:~:text=Destructive%20hail%20triggered%20by%20climate,energy%20losses%20from%20wind%20farms>

### A Benefit-Cost Analysis of Impact-Resistant Asphalt Shingle Roofing

"Climate change will worsen future hailstorms, making impact-resistant shingles more valuable and the yellow area bigger"

<https://www.iclr.org/wp-content/uploads/2022/04/Benefit-cost-analysis-of-Impact-resistant-asphalt-shingle-roofing2.pdf>

### Climate Change Ranks as Top Concern for Insurers, Replacing Pandemic.

<https://www.insurancejournal.com/news/international/2021/09/29/634207.htm>

### The \$5 trillion insurance industry faces a reckoning. Blame climate change.

<https://www.vox.com/22686124/climate-change-insurance-flood-wildfire-hurricane-risk>

### Climate change and P&C insurance:

The threat and opportunity (...) Business models must adapt.

<https://www.mckinsey.com/industries/financial-services/our-insights/climate-change-and-p-and-c-insurance-the-threat-and-opportunity>

### The climate crisis is here. Are insurance companies keeping up?

<https://www.marketplace.org/2021/08/06/the-climate-crisis-is-here-are-insurance-companies-keeping-up/>

### Climate risks for insurers:

Why the industry needs to act now to address climate risk on both sides of the balance sheet.

<https://www.spglobal.com/esg/insights/climate-risks-for-insurers-why-the-industry-needs-to-act-now-to-address-climate-risk-on-both-sides-of-the-balance-sheet>



TO GO FURTHER

# Pressures of **climate change** on the insurance industry

**Insurance companies are now modifying insurance reglementation concerning homeowners' roofs.**

- Stop insuring roofs older than 15 years of age
- Prorated insurance coverage for roofs older than 15 years
- Premiums increasing
- Deductibles increasing
- Insurance companies dropping homeowners' insurances

**Why are insurances companies reducing the insurable roof age to 15 years?**

Because the actuarial assessment concludes that beyond 15 years of age, risks of damages and water infiltrations are increasing exponentially due to the limited lifespan of average asphalt shingle roofs.

