

# Silicon Anode for Li-ion Batteries

## Patent Landscape Analysis – April 2022

*How have industry leaders and start-ups positioned their pawns to address the glorious potential of silicon anode-based Li-ion batteries?*



### REPORT OUTLINE

- Silicon anode for Li-ion batteries
- Patent landscape analysis
- April 2022
- PDF >180 slides
- Excel file >24,700 patents
- Ref.: KM22002
- €4,990 for a multi-user license

### KEY FEATURES OF THE REPORT

- **IP trends**, including time evolution of published patents and countries of patent filings.
- Ranking of **main patent assignees**.
- **Newcomers** in the IP landscape.
- Patent categorization by **supply chain segments** (anode materials, anode, binder, electrolyte, battery cell, etc.).
- **IP position of key players**, and relative **strength** of their patent portfolios.
- **Current main technological approaches**.
- **IP profiles of 17 key players**, including **IP dynamics**, **legal status** and **geographical coverage** of patents, **IP strategies**, **key patents** and **recent IP developments**.
- **Excel database** with all patents analyzed in the report, including patent segmentation and hyperlinks to an **updated online database**.

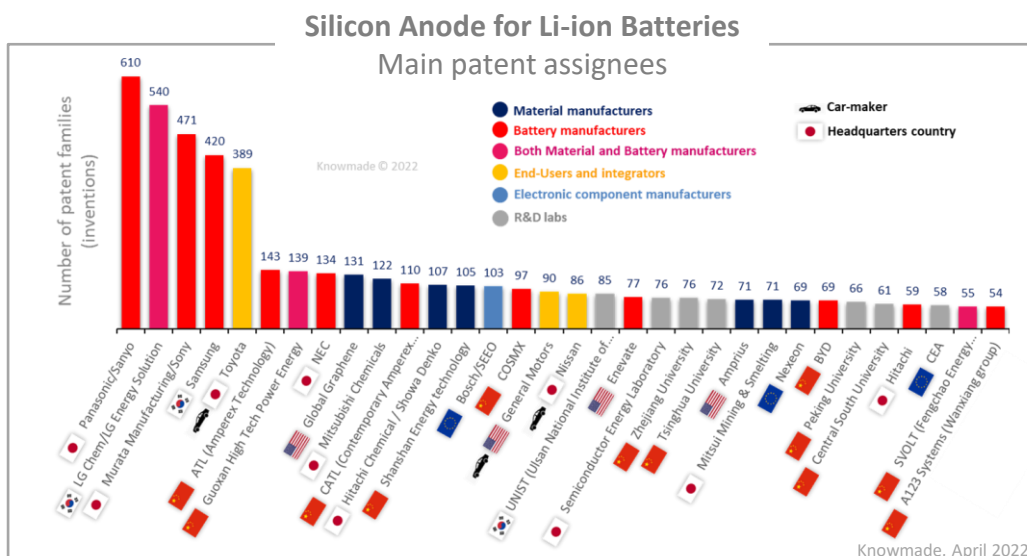
### RELATED REPORTS & MONITORS

- [Solid-State Li-ion Batteries with Inorganic Solid Electrolytes Patent Landscape 2021](#)
- [Solid-State Batteries Patent Monitor](#)

### The Silicon anode-related patent landscape is very dynamic

Automotive represents a **huge new potential market for the battery industry**. Electric vehicle (EV) performances mainly rely on batteries, and **companies operating in this field are investing a lot** to meet their requirements in terms of autonomy, energy density, charge duration, lifetime and safety. R&D developments in the battery field are constantly increasing and multiplying at all supply chain levels. One solution envisioned to **improve battery performances** is to develop new **silicon-based anode** to replace graphite. Indeed, silicon anode-based Li-ion batteries show higher electro-chemical performances, and silicon is environmentally friendly and low-cost material. The cumulative funding for **silicon anode start-ups** reached \$1.9B in 2021 (source: [IdTechEx](#)), and the global **silicon battery market size** is estimated to grow from \$38M in 2020 to \$177M by 2025 at a CAGR of 36.2% (source: [MarketsandMarkets](#))

In this context, **Knowmade** is releasing a new **patent landscape report** covering the whole supply chain of **silicon anode-based Li-ion batteries**, from anode materials, electrodes and binders, to battery cells, electrolytes and equipment. **Silicon anodes** for Li-ion batteries is a booming industry, and the level of **intellectual property (IP) activity is growing fast** with numerous **newcomers** entering the game. **Patent landscape analysis** is the perfect complement to market research, to fully comprehend the **competitive landscape** and **technology roadmap**, keep up with new technology developments, anticipate future technology adoption, and understand the different competitors' strategies. This kind of patent landscape report reveals the **companies, technical solutions** and **strategies** not identified through standard market analysis.



**Knowmade's** analysts have selected and analyzed more than 24,700 patents and patent applications grouped in more than **12,300 patent families** (inventions) related to the **whole supply chain of silicon anode-based Li-ion batteries** (electrode materials, electrodes, electrolytes, battery cells). We have identified more than **1,800 different patent assignees** involved in the Silicon anode patent landscape.

The significant proportion of patents granted worldwide reflects a certain **maturity of silicon anode technology** for Li-ion batteries which is now being adopted by the industry. Nevertheless, numerous patent applications are still pending, meaning that R&D developments are still ongoing to solve technical issues related to silicon anode batteries.

**Leading IP players and IP newcomers across the supply chain**

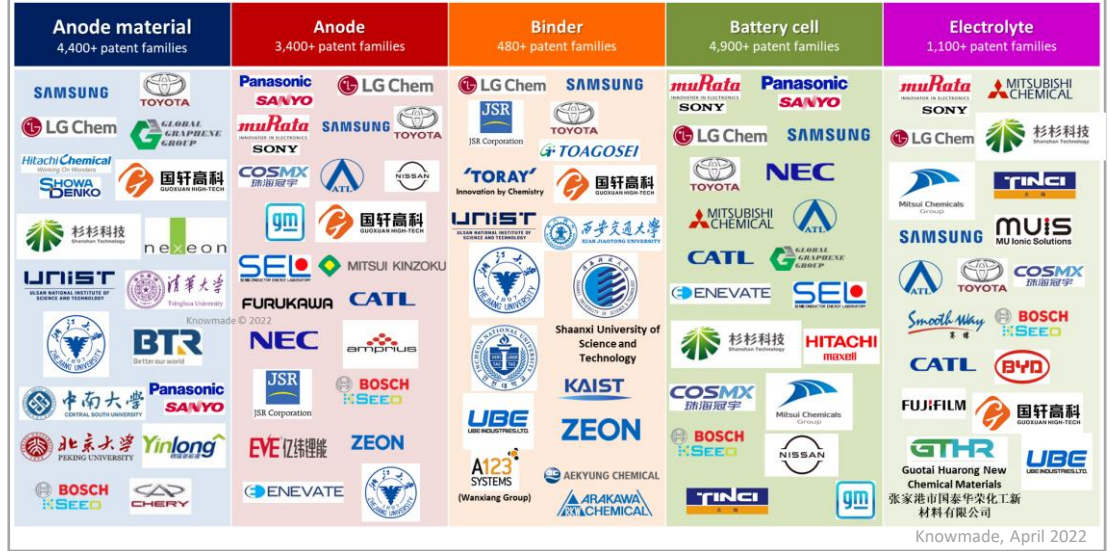
The report provides a clear overview of the **most active patent applicants** as well as a presentation of **newcomers** to the patent landscape. Furthermore, patent segmentation reveals the **IP position of patent assignees by supply chain segments** (anode material, electrode, battery cell) and highlights their **key patent** and **recent IP developments** for **silicon anode materials** (morphologies, compositions, manufacturing processes). Special attention has been paid to **start-ups** and **Chinese ecosystem**.

The silicon anode patent landscape was dominated by **Japanese entities** (Hitachi Chemical, Showa Denko, Mitsui, Panasonic/Sanyo, Sony, NEC, Toyota, etc.) and the two major **South Korean battery companies** (LG Chem, Samsung) until the early 2010s, but the IP activity from **Chinese entities** has exploded since 2015, representing today 45% of the patents.

The **Chinese IP leaders** are ATL, Guoxuan High-Tech, CATL, Shanshan Energy, COSMX, SVOLT, New Keli Chemical, EVE Energy and Yinlong Energy. Only a few **Europeans** (Bosch/Seeo, Nexeon and CEA) and **Americans** (Global Graphene, General Motors, Enevate and Amprius) have patents on silicon anodes for Li-ion batteries. The three main **car manufacturers** Toyota, General Motors and Nissan are present in the IP landscape.

We have identified more than **170 IP newcomers** entering the patent landscape the last few years, including **numerous start-ups**: QingTao Energy Development, Sila Nanotechnologies, StoreDot, Wildcat Discovery Technology, Battflex, Coreshell Technologies, 3DBattery, QuantumScape, AnteoTech, Enwires, Blue Current, Graphenix Development, Cenate, Sillion (acquired by Tesla), OneD Materials, Enevate, Amprius, Nexeon, Nanospan, NanoGraf, Group14 Technologies, Qnovo, etc.

**Silicon Anode for Li-ion Batteries**  
Main IP players by supply chain segment



**Focus on key players' patent portfolios**

The report provides a detailed analysis of **17 key IP players** and **most promising IP newcomers**: Samsung, LG Chem/LG Energy Solution, Panasonic/Sanyo, Murata/Sony, CATL, SVOLT, Toyota, Hitachi Chemical/Showa Denko, Shin-Etsu Chemical, Mitsubishi Chemical, BTR New Energy Material, Shanshan Energy, Nexeon, Amprius, StoreDot, Global Graphene, Guoxuan High-Tech. For each player, we summarize their **IP portfolio**, unveil their **IP strategies** by analyzing their **key patents** and **recent IP developments**.

**Understand the technological trends**

The patents have been categorized by **supply chain segment** (anode material, anode, binder, electrolyte, battery cell). The report comprises **specific parts** dedicated to **silicon anode materials, silicon anode** and **battery cell**, in which the key IP players, IP newcomers, key patents and recent IP development related to are analyzed. In this report, Knowmade highlights the **main silicon-based materials** which are envisioned in patents to improve the cyclability and electrochemical performances of silicon anode materials, increase the yields and reduce the cost and environment impact of the material synthesis.

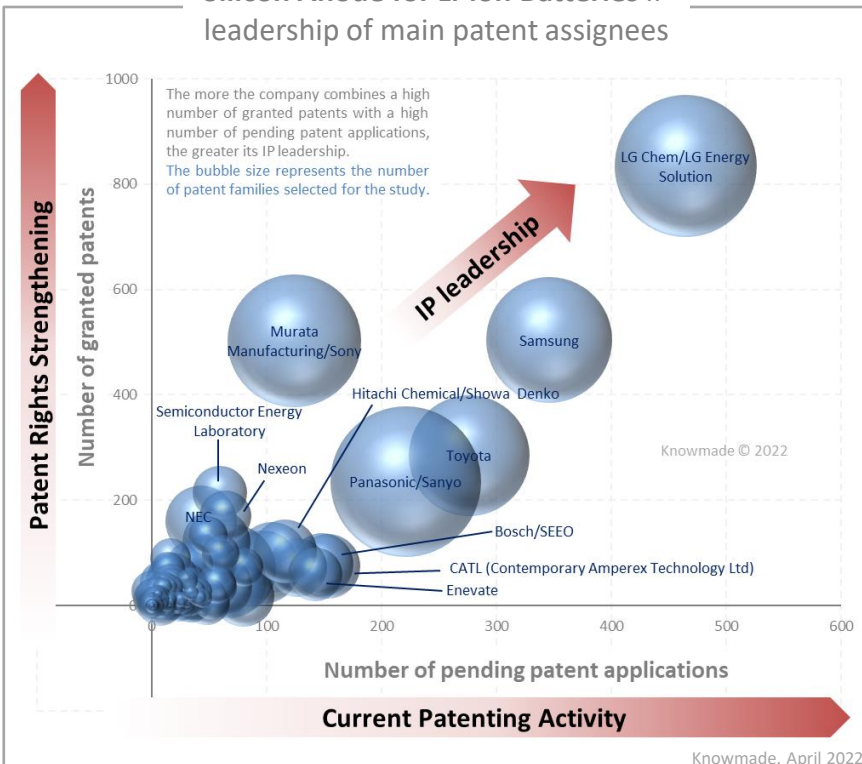
**Useful Excel patent database**

The report also includes an **Excel database** with the 12,300+ patent families (inventions) analyzed in this study.



This useful patent database allows for **multi-criteria searches** and includes patent publication numbers, **hyperlinks to an updated online database** (original documents, legal status, etc.), priority dates, title, abstract, patent assignees, patent's current legal status, and **segments** (anode material, anode, binder, battery cell, electrolyte, equipment, etc.).

**Silicon Anode for Li-ion Batteries IP leadership of main patent assignees**



**Companies mentioned in the report (Non-exhaustive)**

A123 Systems (Wanxiang group), Amprius, ATL (Amperex Technology), BAK Battery, BASF, Bosch/SEEO, BTR New Energy Material, BYD, Canrd New Energy Technology, CATL (Contemporary Amperex Technology Ltd), Chery Automobile, COSMX, Enevate, EVE Energy, Fujifilm, Furukawa, General Motors, Global Graphene, GS Yuasa, Guoxuan High Tech Power Energy, Hitachi, Hitachi Chemical / Showa Denko, Hitachi Maxell, Huawei, Hyundai/Kia, JSR, LG Chem/LG Energy Solution, MGL New Materials, Mitsubishi Chemicals, Mitsui Chemicals, Mitsui Mining & Smelting, MU Ionic Solutions, Murata Manufacturing/Sony, NEC, New Keli Chemical, Nexxon, Nissan, Panasonic/Sanyo, Samsung, Sekisui Chemical, Shanshan Energy technology, Shin Etsu Chemical, SK Innovation, Soundgroup, Sumitomo Electric Industries, Sunwoda, SVOLT (Fengchao Energy Technology), TDK, Tinci Materials Technology, Toshiba, Toyota, Ube Industries, Umicore, Wacker Chemie, Yinlong Energy, Zeon, etc.

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**ABOUT KNOWMADE**

**Knowmade** is a Technology Intelligence and IP Strategy consulting company specialized in analysis of patents and scientific information. The company helps innovative companies and R&D organizations to understand their competitive landscape, follow technology trends, and find out opportunities and threats in terms of technology and patents.

**Knowmade's** analysts combine their strong technology expertise and in-depth knowledge of patents with powerful analytics tools and methodologies to turn patents and scientific information into business-oriented report for decision makers working in R&D, Innovation Strategy, Intellectual Property, and Marketing. Our experts provide prior art search, patent landscape analysis, scientific literature analysis, patent valuation, IP due diligence and freedom-to-operate analysis. In parallel the company proposes litigation/licensing support, technology scouting and IP/technology watch service.

**Knowmade** has a solid expertise in Compound Semiconductors, Power Electronics, Batteries, RF Technologies & Wireless Communications, Solid-State Lighting & Display, Photonics, Memories, MEMS & Solid-State Sensors/Actuators, Semiconductor Manufacturing, Packaging & Assembly, Medical Devices, Medical Imaging, Microfluidics, Biotechnology, Pharmaceuticals, and Agri-Food.

# ORDER FORM

## Silicon Anode for Li-ion Batteries

Patent Landscape Analysis – April 2022

Ref.: KM22002

### SHIP TO

Name (Mr/Ms/Dr/Pr):

Job Title:

Company:

Address:

City:

State:

Postcode/Zip:

Country:

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Date:

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To pay your invoice using a check, please mail your check to the following address:

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06560 Valbonne Sophia Antipolis  
FRANCE

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IBAN: FR76 1460 7003 6360 6214 5695 139  
BIC/SWIFT: CCBPFRPPMAR

#### Paypal

In order to pay your invoice via PAYPAL, you must first register at [www.paypal.com](http://www.paypal.com). You can send money to the KnowMade S.A.R.L. by entering our email address [contact@knowmade.fr](mailto:contact@knowmade.fr) as the recipient and entering the invoice amount.

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For price in dollars, please use the day's exchange rate.  
For French customer, add 20% for VAT.  
All reports are delivered electronically in pdf format at payment reception.

*\*The report can be shared with the employees of the company purchasing the report. Subsidiaries and joint-ventures are excluded. Please be aware that the report is watermarked on each page, with the name of the recipient and the organization (the name mentioned in the PO). This watermark also reaffirms that report sharing is not allowed.*

I hereby accept Knowmade's Terms and Conditions of Sale  
Signature:

# TERMS AND CONDITIONS OF SALES

## Definitions

“Acceptance”: Action by which the Buyer accepts the terms and conditions of sale in their entirety. It is done by signing the purchase order which mentions “I hereby accept Knowmade’s Terms and Conditions of Sale”.

“Buyer”: Any business user (i.e. any person acting in the course of its business activities, for its business needs) entering into the following general conditions to the exclusion of consumers acting in their personal interests.

“Contracting Parties” or “Parties”: The Seller on the one hand and the Buyer on the other hand.

“Intellectual Property Rights” (“IPR”) means any rights held by the Seller in its Products, including any patents, trademarks, registered models, designs, copyrights, inventions, commercial secrets and know-how, technical information, company or trading names and any other intellectual property rights or similar in any part of the world, notwithstanding the fact that they have been registered or not and including any pending registration of one of the above mentioned rights.

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“Products”: Reports are established in PowerPoint and delivered on a PDF format and the database may include Excel files.

“Seller”: Based in Sophia Antipolis (France headquarters), Knowmade is a technology intelligence company specialized in the research and analysis of scientific and technical information. We provide patent landscapes and scientific state of the art with high added value to businesses and research laboratories. Our intelligence digests play a key role to define your innovation and development strategy.

## 1. Scope

1.1 The Contracting Parties undertake to observe the following general conditions when agreed by the Buyer and the Seller. Any additional, different, or conflicting terms and conditions in any other documents issued by the buyer at any time are hereby objected to by the seller, shall be wholly inapplicable to any sale made hereunder and shall not be binding in any way on the seller.

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1.3 Orders are deemed to be accepted only upon written acceptance and confirmation by the Seller, within [7 days] from the date of order, to be sent either by email or to the Buyer’s address. In the absence of any confirmation in writing, orders shall be deemed to have been accepted.

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2.1 Products are sent by email to the Buyer:

- within [1] month from the order for Products already released; or
- within a reasonable time for Products ordered prior to their effective release. In this case, the Seller shall use its best endeavours to inform the Buyer of an indicative release date and the evolution of the work in progress.

2.2 Some weeks prior to the release date the Seller can propose a pre-release discount to the Buyer.

The Seller shall by no means be responsible for any delay in respect of article 2.2 above, and including in cases where a new event or access to new contradictory information would require for the analyst extra time to compute or compare the data in order to enable the Seller to deliver a high quality Products.

2.3 The mailing of the Product will occur only upon payment by the Buyer, in accordance with the conditions contained in article 3.

2.4 The mailing is operated through electronic means either by email via the sales department. If the Product’s electronic delivery format is defective, the Seller undertakes to replace it at no charge to the Buyer provided that it is informed of the defective formatting within 90 days from the date of the original download or receipt of the Product.

2.5 The person receiving the Products on behalf of the Buyer shall immediately verify the quality of the Products and their conformity to the order. Any claim for apparent defects or for non-conformity shall be sent in writing to the Seller within 8 days of receipt of the Products. For this purpose, the Buyer agrees to produce sufficient evidence of such defects.

2.6 No return of Products shall be accepted without prior information to the Seller, even in case of delayed delivery. Any Product returned to the Seller without providing prior information to the Seller as required under article 2.5 shall remain at the Buyer’s risk.

## 3. Price, invoicing and payment

3.1 Prices are given in the orders corresponding to each Product sold on a unit basis or corresponding to annual subscriptions. They are expressed to be inclusive of all taxes. The prices may be reevaluated from time to time. The effective price is deemed to be the one applicable at the time of the order.

3.2 Payments due by the Buyer shall be sent by cheque payable to Knowmade, PayPal or by electronic transfer to the following account:

Banque Populaire Méditerranée, CAP 3000 Quartier du lac, 06700 St Laurent du Var

BIC or SWIFT code: CCBPFRPPMAR

IBAN: : FR76 1460 7003 6360 6214 5695 139

To ensure the payments, the Seller reserves the right to request down payments from the Buyer. In this case, the need of down payments will be mentioned on the order.

3.3 Payment is due by the Buyer to the Seller within 30 days from invoice date, except in the case of a particular written agreement. If the Buyer fails to pay within this time and fails to contact the Seller, the latter shall be entitled to invoice interest in arrears based on the annual rate Refi of the «BCE» + 7 points, in accordance with article L. 441-6 of the French Commercial Code. Our publications (report, database, tool...) are delivered only after reception of the payment.

3.4 In the event of termination of the contract, or of misconduct, during the contract, the Seller will have the right to invoice at the stage in progress, and to take legal action for damages.

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4.1 The Buyer or any other individual or legal person acting on its behalf, being a business user buying the Products for its business activities, shall be solely responsible for choosing the Products and for the use and interpretations he makes of the documents it purchases, of the results he obtains, and of the advice and acts it deduces thereof.

4.2 The Seller shall only be liable for (i) direct and (ii) foreseeable pecuniary loss, caused by the Products or arising from a material breach of this agreement

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b) any claim attributable to errors, omissions or other inaccuracies in the Product or interpretations thereof.

4.4 All the information contained in the Products has been obtained from sources believed to be reliable. The Seller does not warrant the accuracy, completeness adequacy or reliability of such information, which cannot be guaranteed to be free from errors.

4.5 All the Products that the Seller sells may, upon prior notice to the Buyer from time to time be modified by or substituted with similar Products meeting the needs of the Buyer. This modification shall not lead to the liability of the Seller, provided that the Seller ensures the substituted Product is similar to the Product initially ordered.

4.6 In the case where, after inspection, it is acknowledged that the Products contain defects, the Seller undertakes to replace the defective products as far as the supplies allow and without indemnities or compensation of any kind for labor costs, delays, loss caused or any other reason. The replacement is guaranteed for a maximum of two months starting from the delivery date. Any replacement is excluded for any event as set out in article 5 below.

4.7 The deadlines that the Seller is asked to state for the mailing of the Products are given for information only and are not guaranteed. If such deadlines are not met, it shall not lead to any damages or cancellation of the orders, except for non-acceptable delays exceeding [4] months from the stated deadline, without information from the Seller. In such case only, the Buyer shall be entitled to ask for a reimbursement of its first down payment to the exclusion of any further damages.

4.8 The Seller does not make any warranties, express or implied, including, without limitation, those of saleability and fitness for a particular purpose, with respect to the Products. Although the Seller shall take reasonable steps to screen Products for infection of viruses, worms, Trojan horses or other codes containing contaminating or destructive properties before making the Products available, the Seller cannot guarantee that any Product will be free from infection.

## 5. Force majeure

The Seller shall not be liable for any delay in performance directly or indirectly caused by or resulting from acts of nature, fire, flood, accident, riot, war, government intervention, embargoes, strikes, labor difficulties, equipment failure, late deliveries by suppliers or other difficulties which are beyond the control, and not the fault of the Seller.

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6.1 All the IPR attached to the Products are and remain the property of the Seller and are protected under French and international copyright law and conventions.

6.2 The Buyer agreed not to disclose, copy, reproduce, redistribute, resell or publish the Product, or any part of it to any other party other than employees of its company. The Buyer shall have the right to use the Products solely for its own internal information purposes. In particular, the Buyer shall therefore not use the Product for purposes such as:

- Information storage and retrieval systems;
- Recordings and re-transmittals over any network (including any local area network);
- use in any timesharing, service bureau, bulletin board or similar arrangement or public display;
- Posting any Product to any other online service (including bulletin boards or the Internet);
- Licensing, leasing, selling, offering for sale or assigning the Product.

6.3 The Buyer shall be solely responsible towards the Seller of all infringements of this obligation, whether this infringement comes from its employees or any person to whom the Buyer has sent the Products and shall personally take care of any related proceedings, and the Buyer shall bear related financial consequences in their entirety.

6.4 The Buyer shall define within its company point of contact for the needs of the contract. This person will be the recipient of each new report in PDF format. This person shall also be responsible for respect of the copyrights and will guaranty that the Products are not disseminated out of the company.

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7.1 If the Buyer cancels the order in whole or in part or postpones the date of mailing, the Buyer shall indemnify the Seller for the entire costs that have been incurred as at the date of notification by the Buyer of such delay or cancellation. This may also apply for any other direct or indirect consequential loss that may be borne by the Seller, following this decision.

7.2 In the event of breach by one Party under these conditions or the order, the non-breaching Party may send a notification to the other by recorded delivery letter upon which, after a period of thirty (30) days without solving the problem, the non-breaching Party shall be entitled to terminate all the pending orders, without being liable for any compensation.

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All the provisions of these Terms and Conditions are for the benefit of the Seller itself, but also for its licensors, employees and agents. Each of them is entitled to assert and enforce those provisions against the Buyer.

Any notices under these Terms and Conditions shall be given in writing. They shall be effective upon receipt by the other Party.

The Seller may, from time to time, update these Terms and Conditions and the Buyer, is deemed to have accepted the latest version of these terms and conditions, provided they have been communicated to him in due time.

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9.1 Any dispute arising out or linked to these Terms and Conditions or to any contract (orders) entered into in application of these Terms and Conditions shall be settled by the French Commercial Courts of Grasse, which shall have exclusive jurisdiction upon such issues.

9.2 French law shall govern the relation between the Buyer and the Seller, in accordance with these Terms and Conditions.