How Can We Keep Plastic Off the Oceans?

Supply Chain Control Using Phosphorescence

How Does Plastic Waste Actually End Up in the Oceans?

Around 80% of the plastic that ends up in the oceans comes from rivers, which is why many initiatives focus on intercepting plastic waste before it reaches the sea. Other organizations, mostly of a local nature, concentrate on cleaning up beaches, removing the plastic waste that has washed up on them.

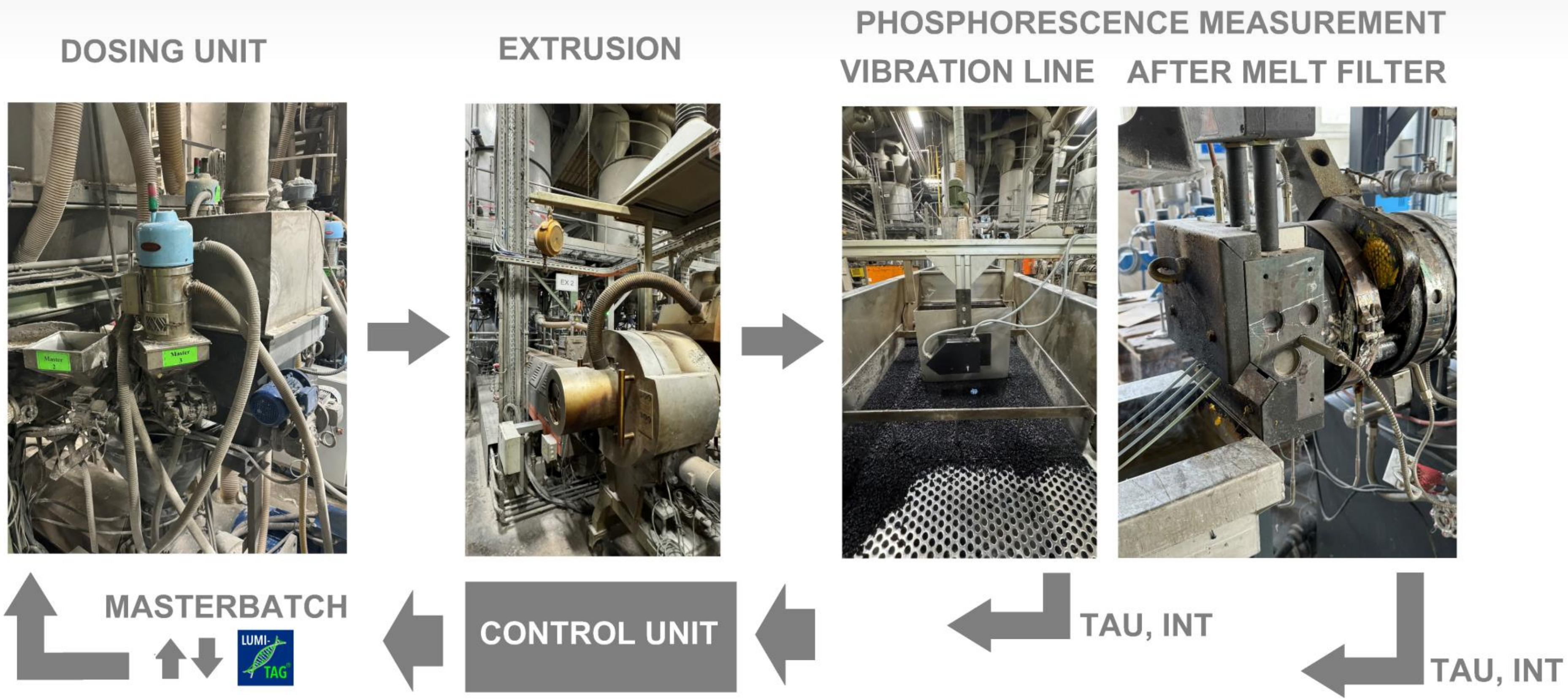
In contrast, the collection of plastic in the open sea is technically very challenging. Various initiatives remove plastic from garbage patches, such as the Great Pacific Garbage Patch. However, this proportion is still relatively low compared to the quantities of plastic waste collected from the rivers.

From the Collection and Processing of Plastic Waste to the Production of Recyclates

Once the plastic waste has been collected and packed, it is forwarded to the recycling plant in compliance with supply chain controls.
The process here is similar to the usual plastic waste processing: pre-sorting, shredding, washing, drying and fine sorting of the flakes before they finally enter the extruder.

The Extrusion Process

A reliable method of identifying whether a recyclate was actually made from plastic waste originating from the sea, river or beach is the so-called marker-based process. In this process, a masterbatch with a luminescent inorganic marker is added with the help of a dosing unit.
The dosing quantity can be determined using a suitable sensor system and regulated via a control system. The sensor system is installed in the extruder, immediately after the melt filter, or on the vibrating chute after granulation.



MARKER

So How Does It Work With the Marker?

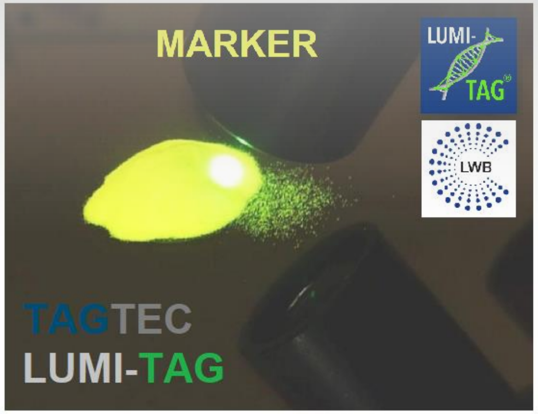
When selecting the markers, it must be ensured that they can withstand the high temperatures and pressures in the extrusion system. Furthermore, they must provide a significant and individual signal response, which can also be detected at extremely low marker concentrations down to the two-digit ppm range. The marker particle size is in the range of a few µm. Suitable inorganic markers are contained in the masterbatches of the TAGTEC and LUMI-TAG brands.

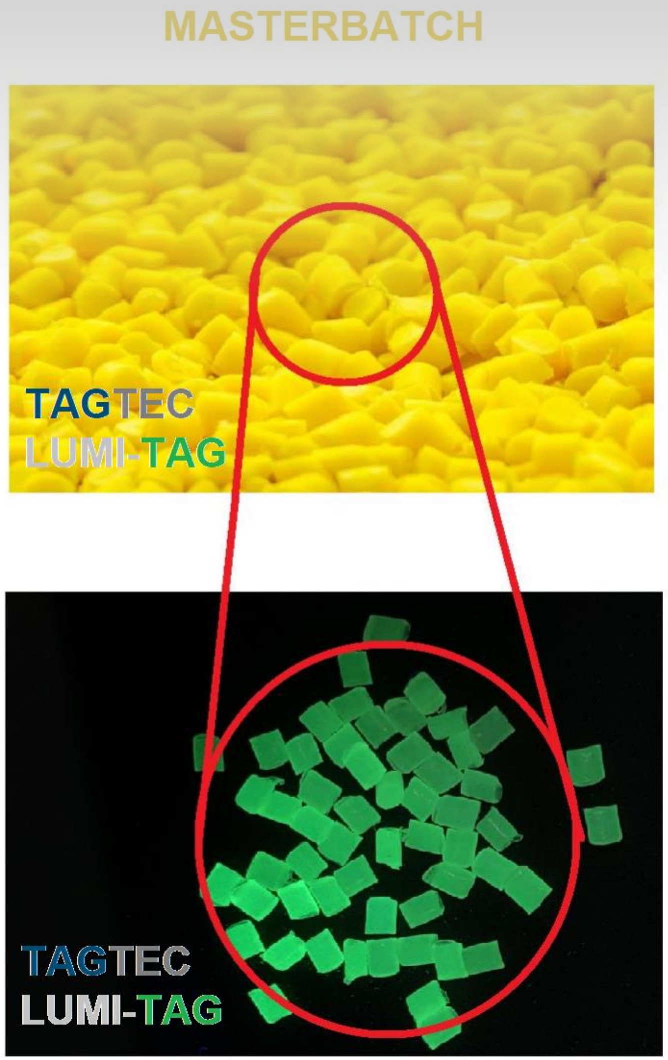
LUMI-TAG®

LWB

TAGTEC

The Fluorescent or Phosphorescent Marker Is Embedded in the Masterbatch

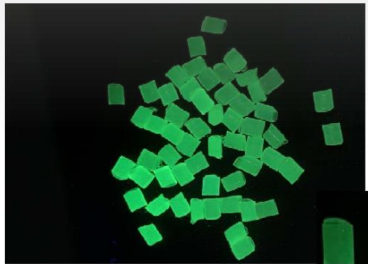




During the production of the masterbatch, care is taken to ensure that the quantity of marker in particular is constant and that the marker is distributed homogeneously in the masterbatch.

Homogeneous Distribution of the Marker Particles in the Masterbatch Is Ensured During the Manufacturing Process

A closer look at the pellets with the TAGTEC or LUMI-TAG masterbatch shows this:



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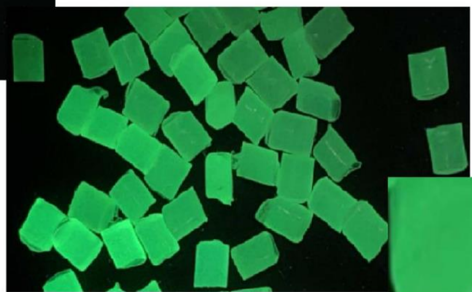
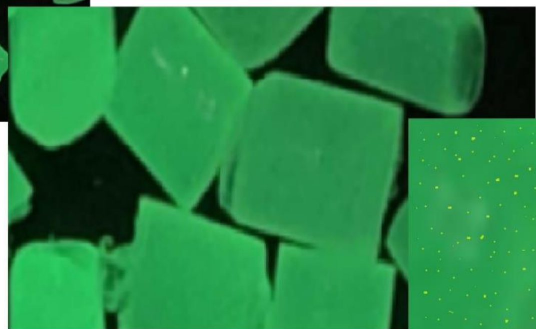
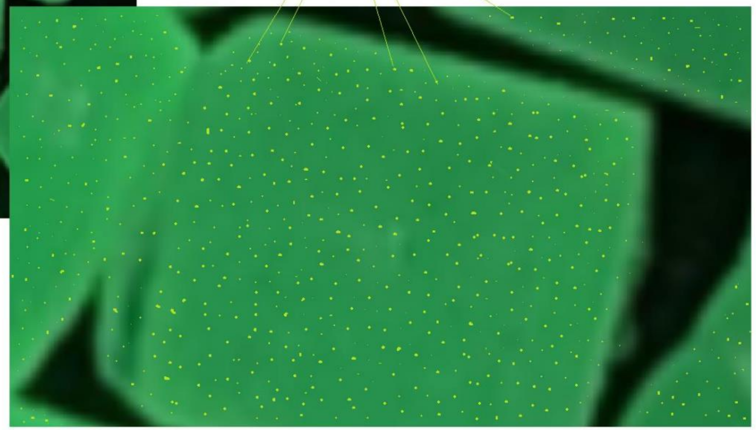




If you zoom into the TAGTEC or LUMI-TAG masterbatch until only one grain is visible under the camera, the individual particles (here UVA exciteable particles) become visible. The size of the marker particles is in the range of 1µm and 10µm.

LUMI-TAG
TAGTEC
PARTICLES

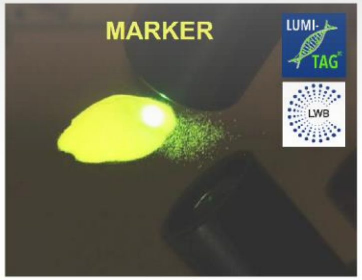


LUMI-TAG®

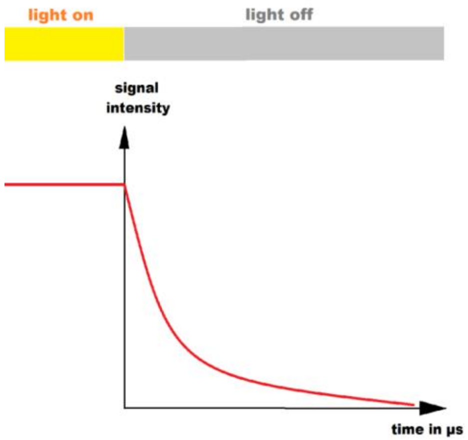
TAGTEC

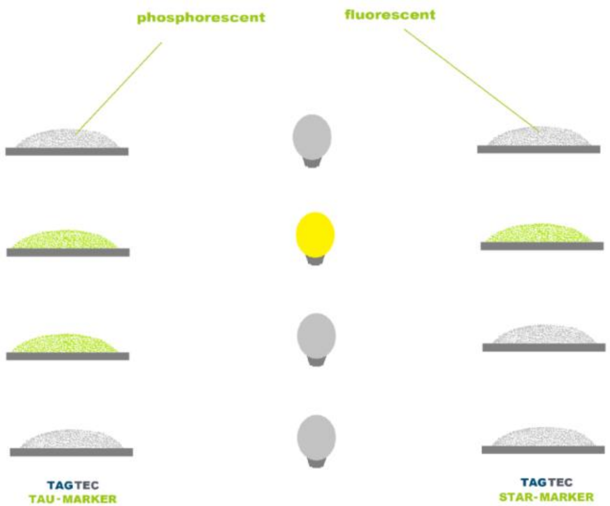
Fluorescent and Phosphorescent TAGTEC and LUMI-TAG Markers

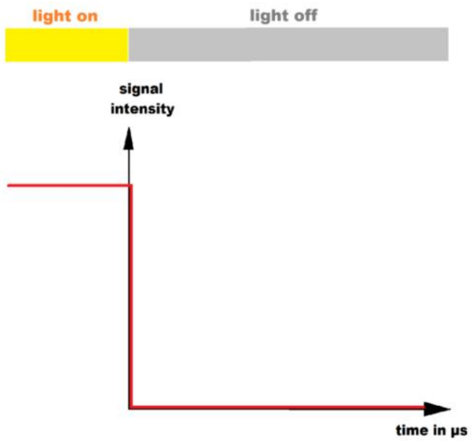
The afterglow of the phosphorescent marker decreases exponentially after the primary light source has gone out. After a few hundred microseconds, depending on the respective marker, the afterglow decreases to zero.



The fluorescent marker only lights up as long as the primary light source is switched on and therefore goes out immediately when the excitation light source is switched off.







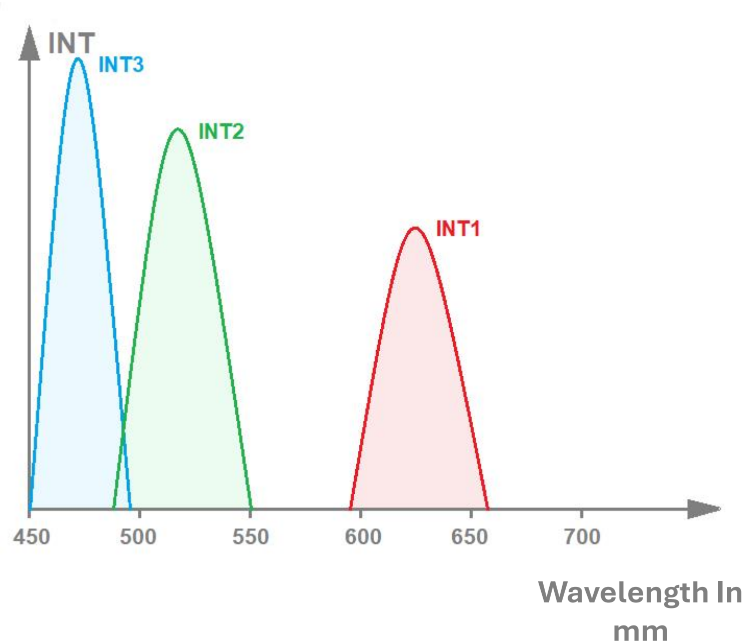
LUMI-TAG®

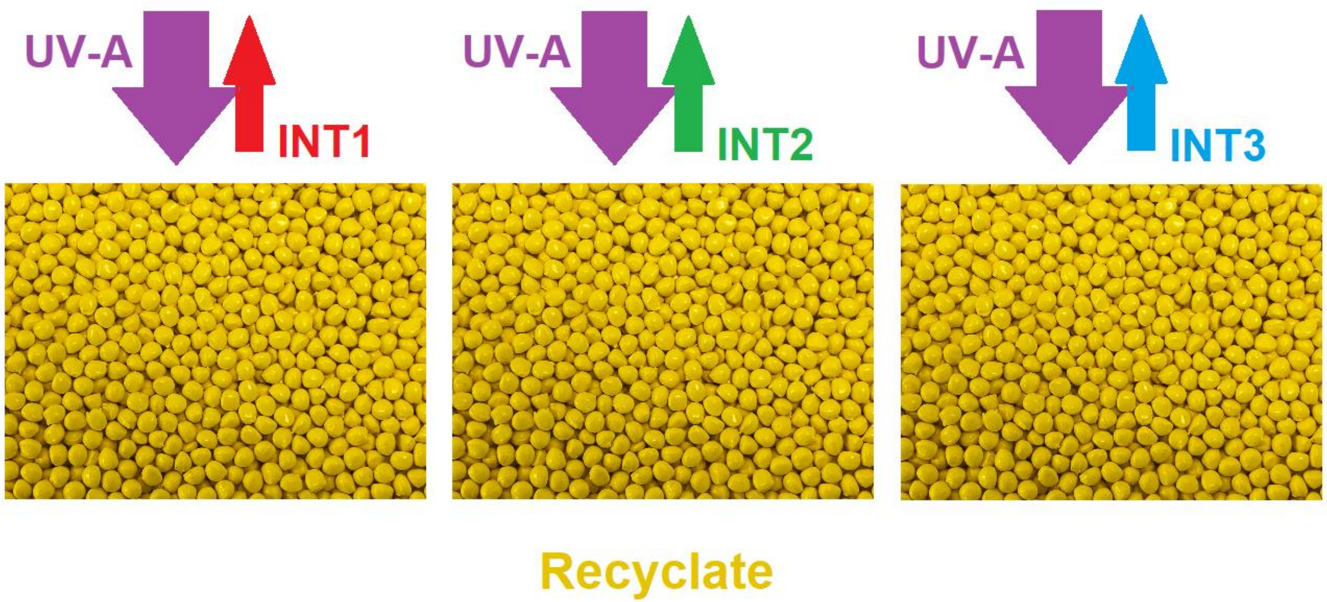
LWB

TAGTEC

Fluorescent TAGTEC and LUMI-TAG Markers

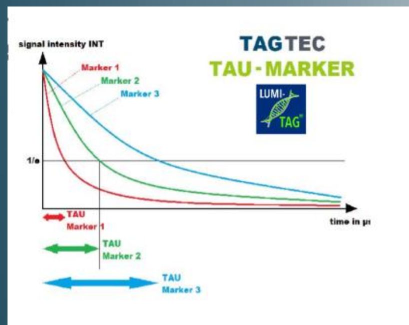
Typically, fluorescent markers are excited with UV-A light (but there are also markers that are excited with blue light, for example). Depending on the respective marker type, a glow in the visible wavelength range can be observed upon excitation.
This fluorescent marker behavior can be measured with detectors from Sensor Instruments GmbH. The SPECTRO-3-30-UV/BL-MSM-ANA or the SPECTRO-T-1-200-UV/BL are suitable for this purpose.

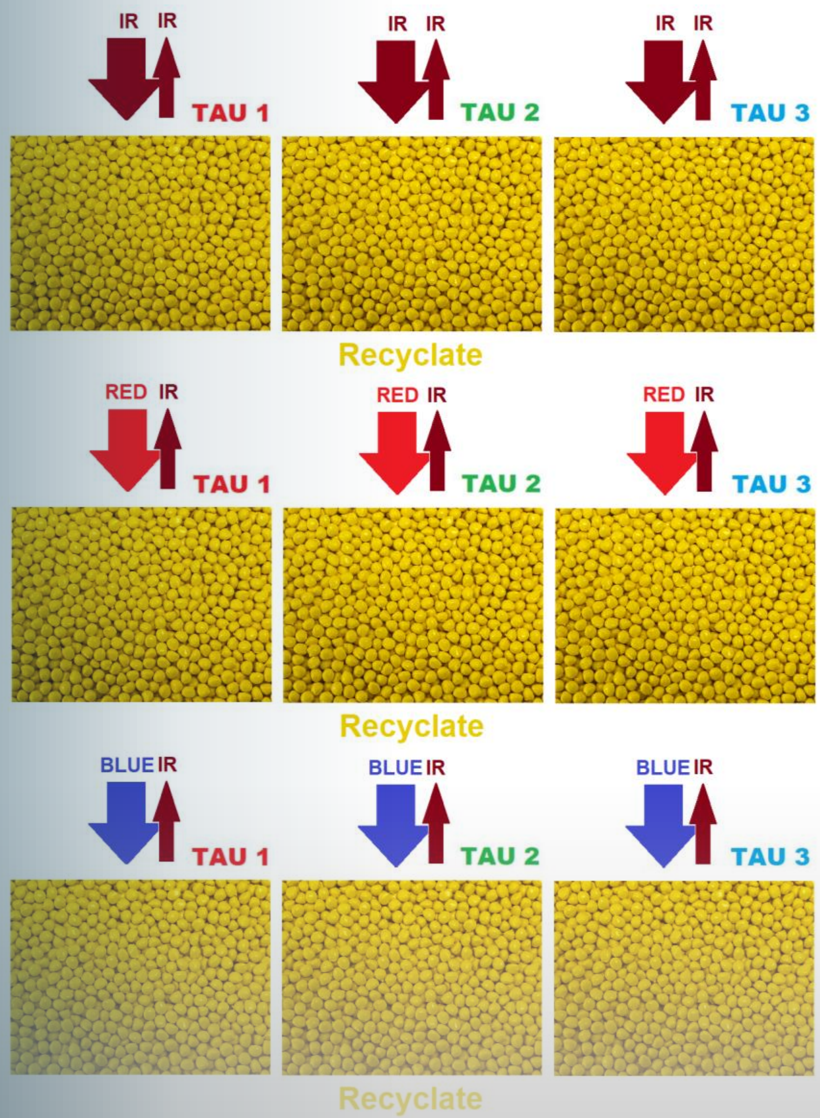




Typical Representatives of Phosphorescent Markers

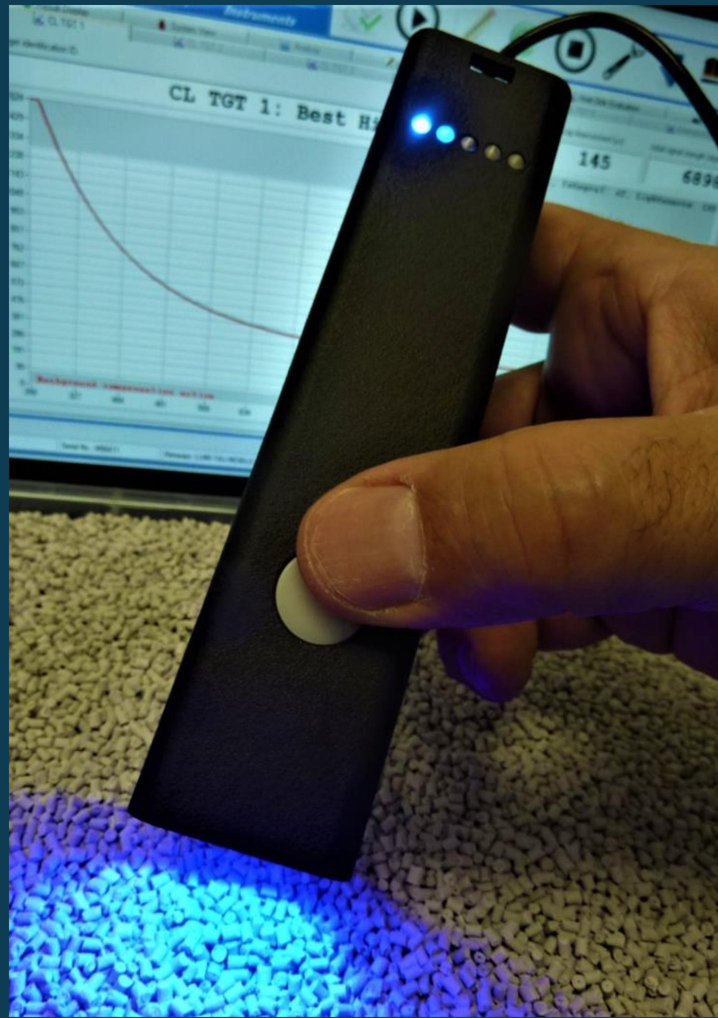
Depending on the marker type, UV-A, visible or IR light can be used for excitation. In practice, markers that can be excited in the IR range are commonly used. However, markers that can be excited in the red, blue or UV-A wavelength range are also used.





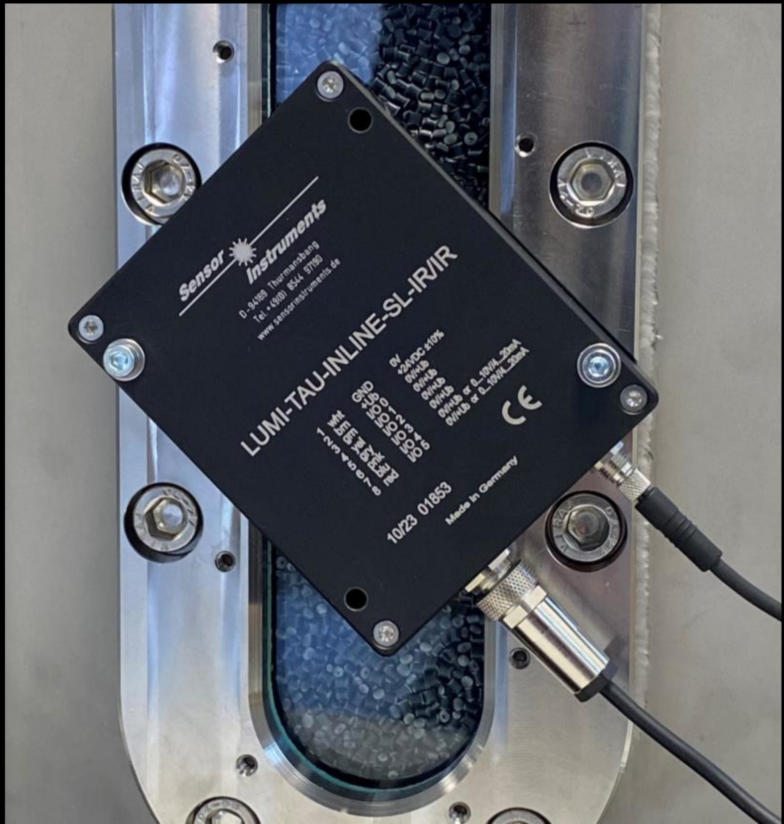
The decay time (defined by the time constant TAU) is significant for the respective marker.
A mixture, e.g. of an IR and red excitable marker, is therefore also conceivable, as there is no mutual interference due to the different excitation wavelengths. With the LUMI-TAU-INLINE and the LUMI-TAU-MOBILE series, the time constant and the intensity of the phosphorescence can be determined.

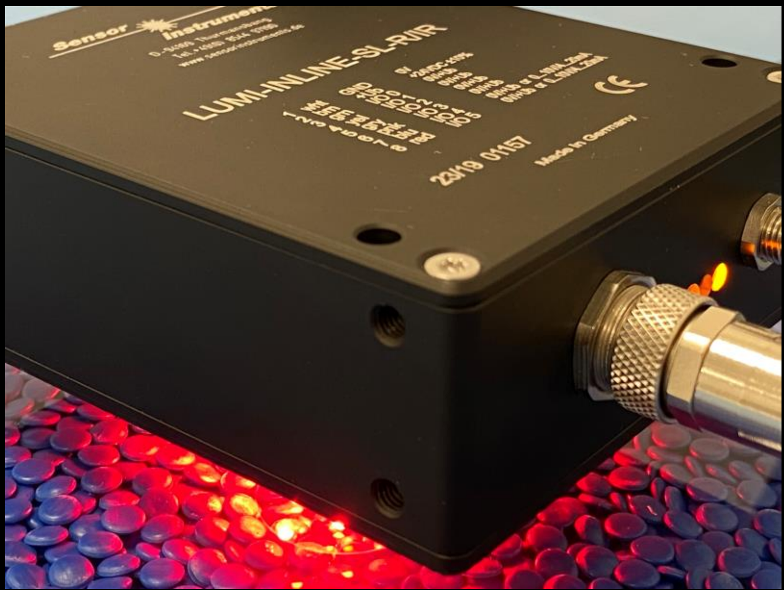
The LUMI-TAU-MOBILE Series



With the LUMI-TAU-MOBILE hand-held device series, all TAGTEC and LUMI-TAG markers can be detected. The various wavelength ranges (IR, red, blue and UV-A, but also green and yellow) can be covered with this device series. For example, the LUMI-TAU-MOBILE-CL-IR/IR is suitable for IR-excitable and IR-phosphorescent markers, while the LUMI-TAU-MOBILE-CL-RD/IR can be used to detect red-excitable and IR-phosphorescent markers.

All MOBILE devices in the CL series have Bluetooth, a Li-Ion battery and USB-C and can therefore communicate with a smartphone as well as a PC. The TAU and INT data of the respective sample is forwarded to a special app on the smartphone via the Bluetooth interface, e.g. for supply chain control. The five LEDs integrated in the device can be used to display five different products or five different states of the same product. If a product is detected, the corresponding LED lights up green, red if an incorrect marker is present and turquoise if no marker is present.





The LUMI-TAU-INLINE Series

The LUMI-TAU-INLINE sensors can be used to monitor recycled material during production or to monitor the resulting finished parts. All phosphorescent TAGTEC and LUMI-TAG markers can be detected.
The sensors can be mounted both on dosing systems and silos with the aid of sight glasses, but can also be installed above vibrating chutes immediately after granulation.
Various adapters are available for communication with a PC or PLC via RS232, USB, Ethernet or Profinet.

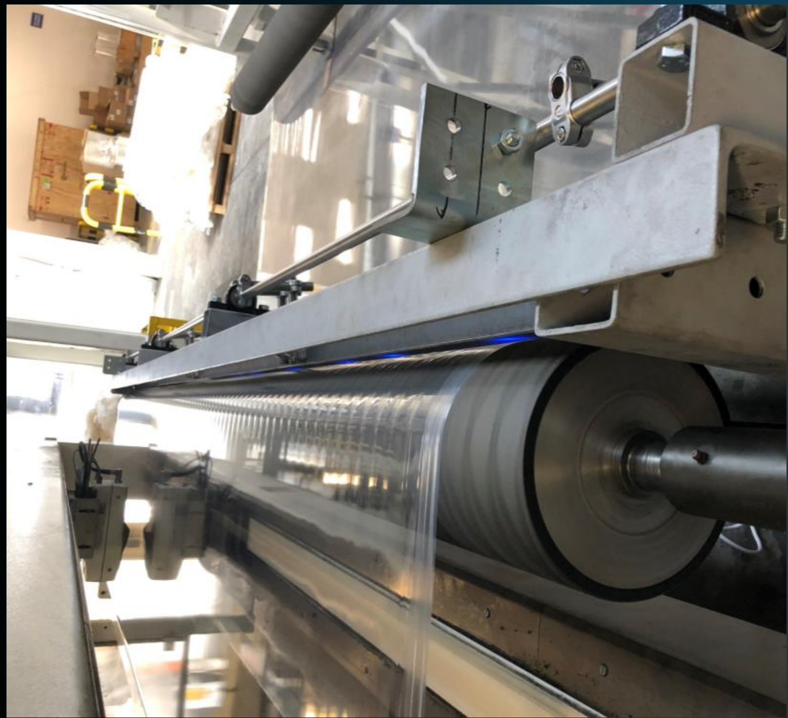
The KL-PROBE Series

One of the first positions where the recyclate can be checked, albeit in liquid form, is immediately after the melt filter of the extruder. The tip of the KL-PROBE looks directly into the plastic melt and measures both the intensity and the time constant TAU of the respective marker in the melt. Various LUMI-TAU-INLINE-FIO-SL-... evaluation electronics are also available for this purpose (UV-A, blue, green, yellow, red, IR excitation and response in the visible or IR range). The stainless steel housing is a standard design with a ½” thread. The KL-PROBE can be used in areas where high temperatures and pressures prevail.

From Recyclate to the Finished Product

Depending on the product to be produced, it is either fed into the extruder or the injection molding machine; in both cases, there is usually a dosing unit upstream of the actual system through which the recyclate is fed.
A version of the LUMI-TAU-INLINE-SL-... (equipped with a UV-A, blue, green, yellow, red or IR LED light source that matches the marker in the respective recyclate) can also be used at this position. The sensor checks whether the correct recyclate with the respective marker (TAU) is present in the correct concentration (INT).

Inline Inspection of the Manufactured Products on an Extrusion Line



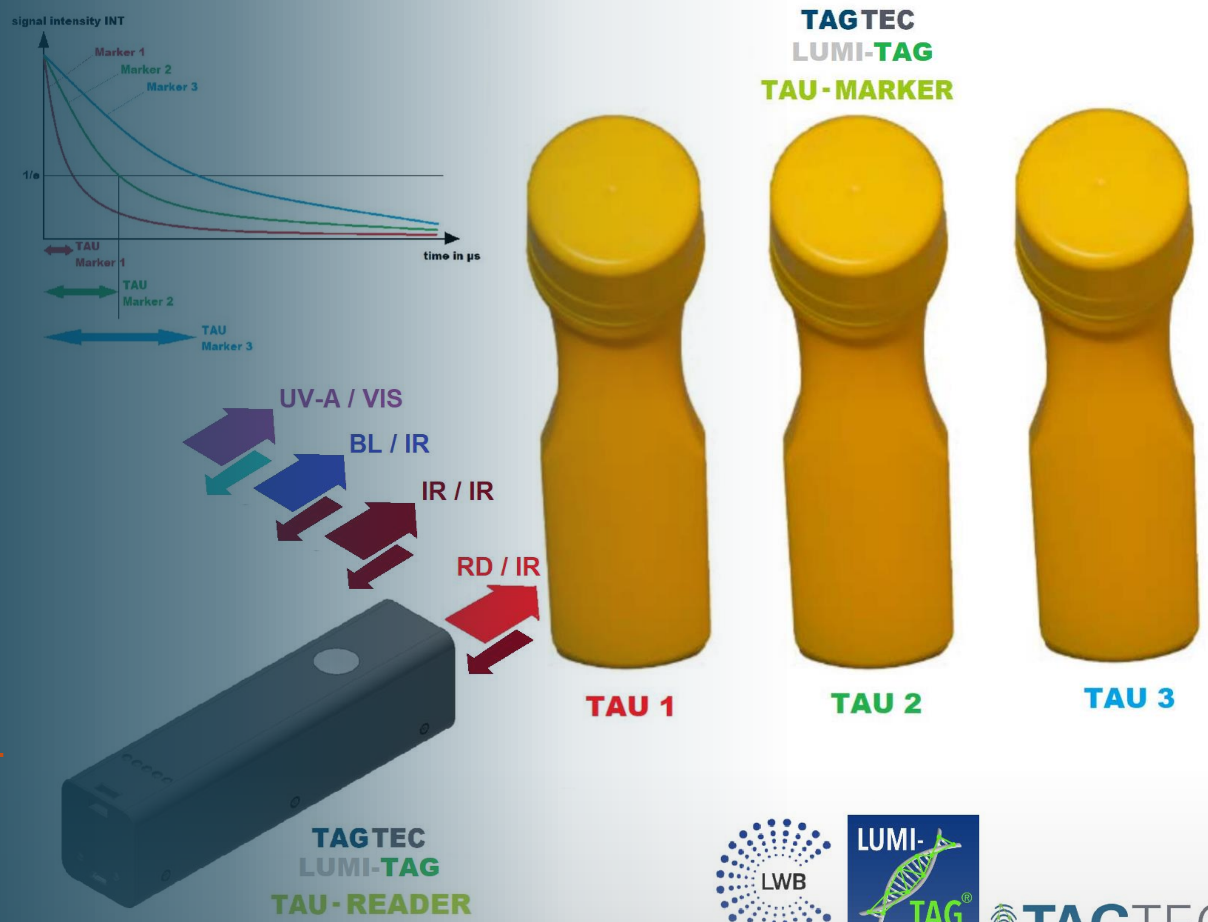
On a 5m wide system, the presence of a TAGTEC or LUMI-TAG marker is checked on a 20µm thick stretch film at various points transversely to the film transport direction. In addition to the TAU value, which provides information about the authenticity of the film, the INT intensity value is used in the further process to determine whether the film is overstretched. The film is produced at a speed of approx. 10 m/s. The homogeneity of the film is checked at the various measuring points transverse to the running direction.

Inline Inspection of Plastic Bottles Produced on a Plastic Injection Molding Machine

During the production of plastic bottles, the marker concentration (INT) should be checked and also whether the correct marker (TAU) has been used, which can be determined by means of the TAU value (time constant). As a rule, the brighter an object is, the lower the marker concentration can be in order to provide a certain INT value required for evaluation. The bright objects act as a reflector, so to speak, allowing more phosphorescent light to reach the sensor.

On the other hand, the marker concentration must be increased for dark objects. As black plastic (carbon black) absorbs NIR light almost completely, the selection of suitable markers is limited. In this case, markers that are excited with UV-A light are used. These markers phosphoresce in the visible wavelength range so that an evaluable signal can be obtained if the marker concentration is sufficient.

Measurement of the TAU Value (Time Constant) and the INT Value (Marker Concentration) on the Finished Product Using Hand-Held Measuring Devices

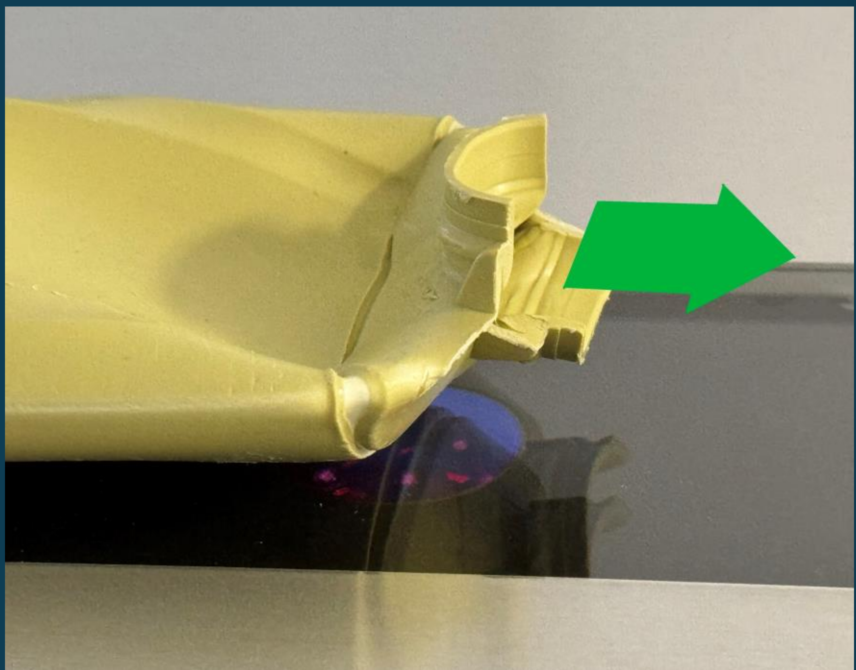


The devices in the LUMI-TAU-MOBILE-CL-... Series are designed for mobile measurement of the TAU and INT value. Depending on the respective marker type, a device with LEDs in UV-A, blue, green, yellow or red is used, red and infrared wavelength range for excitation. As the decay time of the secondary emission (phosphorescence) depends on the respective marker type, several markers with the same excitation wavelength can also be distinguished.

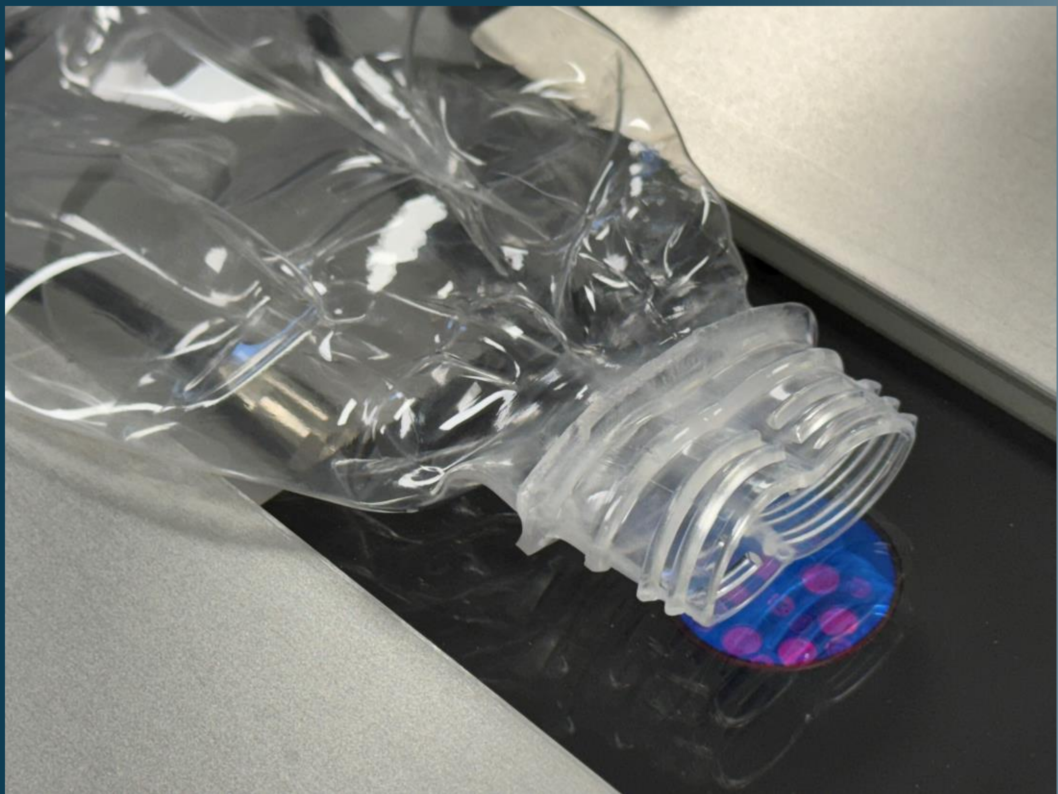
Measurement of the TAU and INT Values in the Laboratory With the LUMI-TAU-INLINE-SL-... Devices, Which Are Mounted Directly Below a Glass Plate Placed in a Plastic Tray

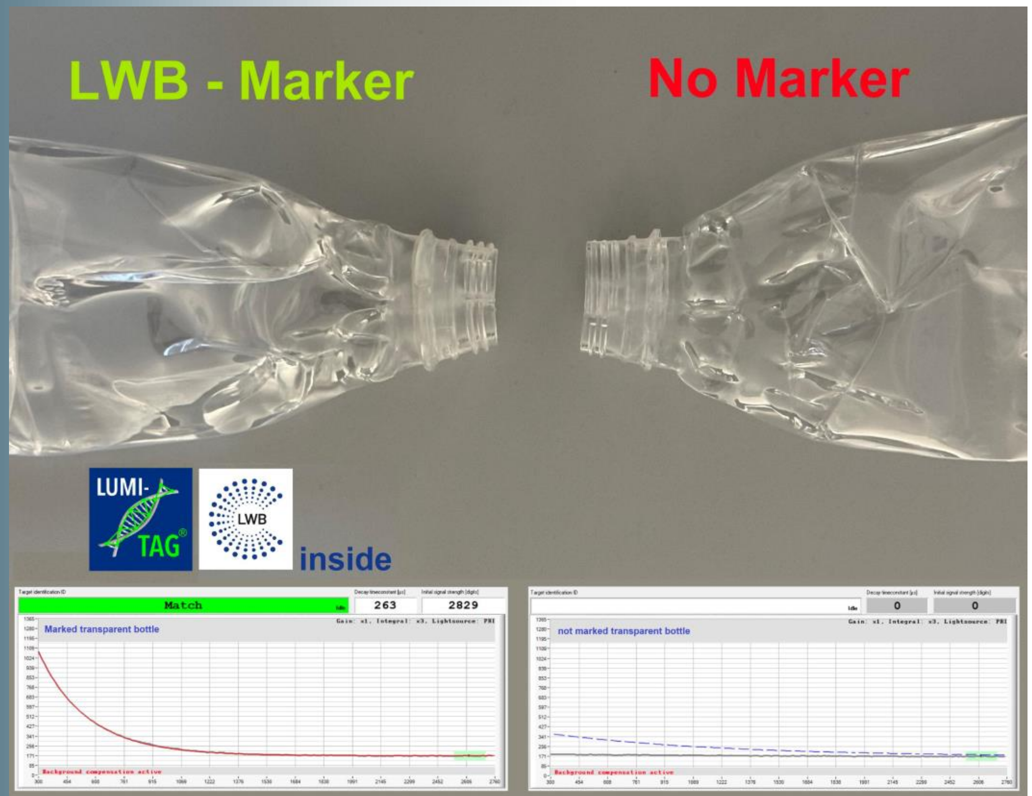
It is very easy to distinguish between marked objects and objects without markers or with markers that differ from the original: The objects to be examined are slid over the glass plate. If a marker is present in the object, a TAU and an INT value are displayed numerically and graphically on the Windows software on the PC.

Distinguishing
the Original from
the Counterfeit Using
LUMI-TAU-INLINE-SL-IR/IR
in the Laboratory



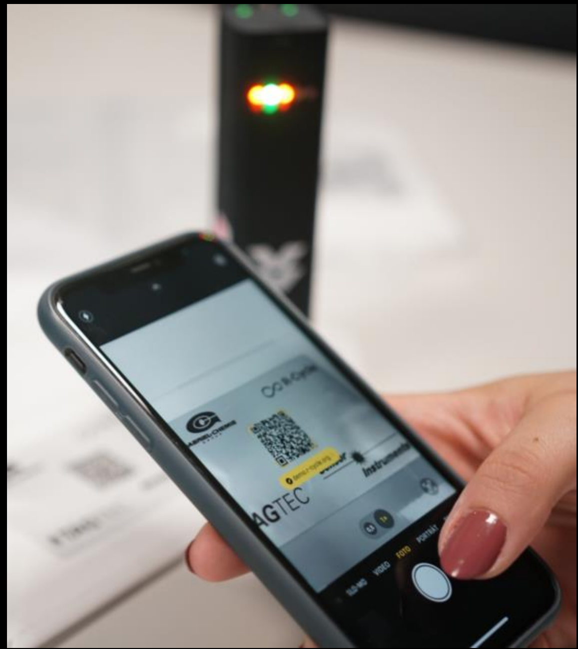
Differentiation of Two Transparent Bottles Using LUMI-TAU-INLINE-SL-IR/IR in the Laboratory, Whereby One Bottle Is a Counterfeit

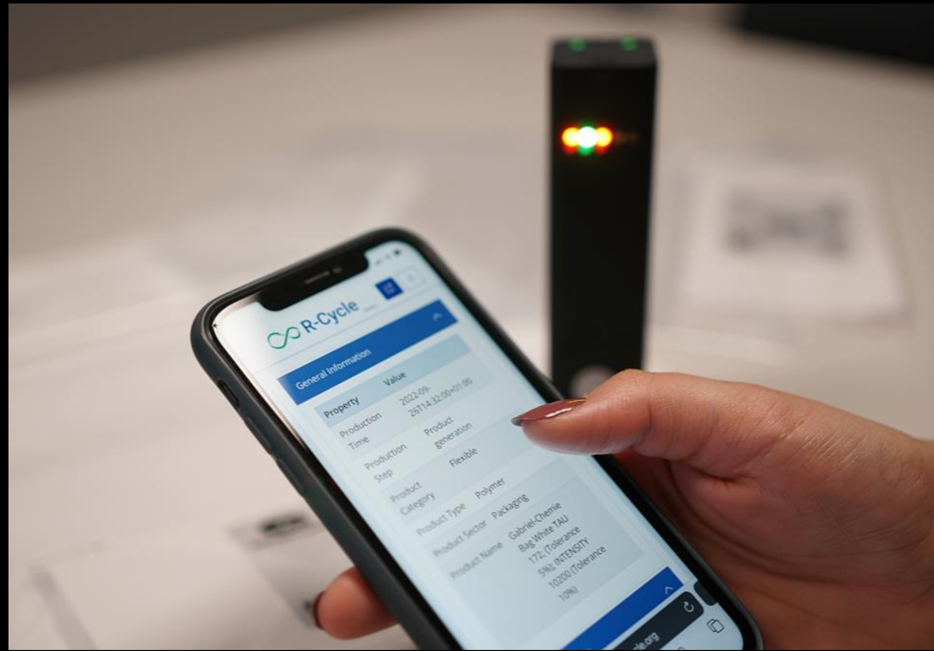




Supply Chain Control with the LUMI-TAU-MOBILE Hand-Held Measuring Device and an App on the Smartphone

For this purpose, the marked objects are provided with a Data Matrix code by laser immediately after production. The LUMI-TAU-MOBILE-CL-... hand-held device (UV-A/BL, BL/IR, RD/IR or IR/IR, depending on the marker type) is used to check whether the TAU and INT values are within the specified tolerances. The TAU and INT values are then transferred to a corresponding app on the smartphone via Bluetooth. If the TAU and INT values are correct, the smartphone evaluates the Data Matrix Code and access to the digital product passport is established.





R-Cycle – the Digital Product Passport for Plastic Products

Plastic bags labeled with a phosphorescent marker, which are also provided with a Data Matrix Code, are to be checked. After checking whether the correct marker is present in the correct concentration, the Data Matrix Code is scanned using the R-Cycle app on the smartphone; the product data is then displayed in the digital product passport.

Individual Data Matrix Code on Marked Plastic Articles

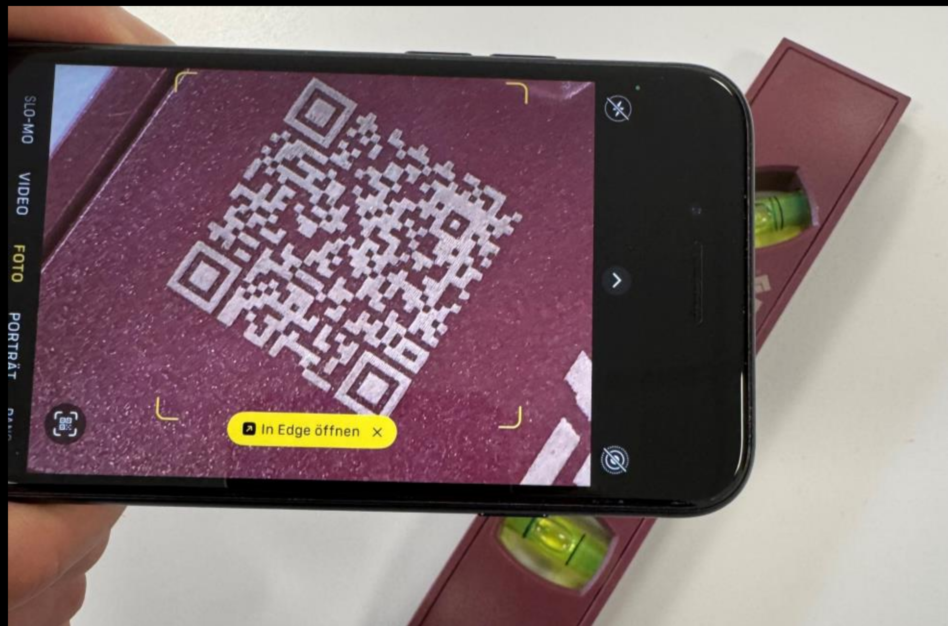
With this method, each object is provided with an individual Data Matrix Code.

During the inspection, the TAU and INT values are first determined using a suitable LUMI-TAU-MOBILE-CL-... hand-held device.
If these two values are within the specified tolerances, the cross-check is carried out with the individual Data Matrix Code and a link to the digital product passport is established.

LUMI-TAG®

LWB

TAGTEC



Clarity about the Origin of the Plastic

Authenticity Check Using a Phosphorescent Marker Embedded in the Plastic Product

Supply chain monitoring over the entire life cycle

Our specialists are happy to tell you more about it

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