Smart Indicators for Time and Temperature in Healthcare

Smart label indicators are on the rise, and they bring many benefits with them – especially during this pandemic – such as the ability to indicate more reliable COVID-19 test results for patients

Nora Murphy at Timestrip

The coronavirus pandemic has brought into sharp relief a number of issues in the healthcare and medtech sectors, which were perhaps less well known previously. Among these is the monitoring of temperature and storage time on products that have a defined shelf life, or are most sensitive to their environment – everything from biological specimens and pharmaceutical products to the humble hospital curtain. Greater sensitivity to infection issues means that today's healthcare professional needs to consider best practice in the deployment of disposable indicators for time and temperature.

Safe chemical-based indicators are a simple approach to monitoring and take the form of 'smart' self-adhesive labels, offering an intuitive visual check for healthcare workers, complementing other important product data when administering pharma, vaccination, or biological products. Relatively low-cost, they can be placed directly on the product or package to be monitored, starting at manufacturing or collection, and staying attached all the way to the end user. The simple labels can be initiated, read and understood by every level of employee that encounters the products.

Pharmaceuticals

High-value pharma products may have long shelf lives, but may degrade much more quickly at elevated temperatures. A supplier of injector pens can be used as a case study: they needed a way to ensure the integrity of its products in the community, and now uses an indicator to measure and report the time for which the temperature rises above 25°C.

In another example, insulin supplies may need to be used within 28 days from opening. Hospitals monitoring their stock against their 'use by' date have found that the clear visual indication from a time indicator label can allow them to check very large quantities quite quickly, and focus their attention on those which are approaching expiry.

Specimen Transport

Samples of body tissue, taken for biopsy, for instance, will need to be tested within a fairly tight time window, such as 72 hours. By deploying a smart time-monitoring label, samples can be given a quick visual check indicating when they are nearing a testing deadline.

Home testing kits can also be tagged with a smart label, which is activated by the customer when the specimen is shipped. As well as for coronavirus, such kits are used in a very wide range of possible conditions including cancer screening, diabetes, and sexually transmitted diseases.

Post-COVID-19 testing of clinical virus specimens has ramped up to very high levels in many countries. Testing large numbers of people is important in understanding how widely the virus has spread, and is a key part of a test and trace strategy. Swab specimens sent to laboratories from hospitals, GP surgeries, or even roadside testing stations will be stored and transported under different conditions. Monitoring of environmental conditions from sampling to testing is crucial to reliable testing.

Virus cultures will degrade over time and die quite quickly as temperatures rise. FDA and WHO regulations state that coronavirus specimens can be stored and transported chilled (2-8°C) for up to 72 hours after collection (1). However, when exposed to temperatures above 50-55°C, coronavirus becomes non-infectious within just a few hours. False negative

tests can result if the virus succumbs between sampling and testing.

An alternative storage technique is freezing the specimens, and virology specimen collection guidelines state that where there is likely to be a delay in specimens reaching the laboratory, the specimens should be frozen to -20°C or ideally -70°C. Additionally, according to WHO regulations, it is important to avoid repeated freezing and thawing of specimens. Indicators are available that are capable of tracking a thawing event. If the ambient temperature rises above 0°C (+/-1°C), the indicator will show the cumulative period of thawing, up to two hours. The clear, irreversible indicator provides peace of mind that viral specimens are suitable for reliable testing.

One of the challenges in developing an effective smart indicator in this context is monitoring both the time for which a specimen has been stored and also the temperatures it has experienced over that time – a complex envelope of these two parameters. An interesting recent development is a smart label formulation which closely follows the time and temperature limitations of acquired specimens even under changing conditions. This time and temperature integrator reflects the accumulated history of the virus specimen during transport and storage, and gives a clear non-reversible visual indication when acceptable conditions have been breached.

A number of indicator products can be found on the market. However, one drawback of some of these products is that they change colour with time, and thus, the breach indication signal is ambiguous and subject to human error – visual interpretations of colour shades, etc. At least one brand overcomes this issue by incorporating a distinct coloured frontline that progresses laterally inside a white bar from one side to the other, providing a distinct indication of an end point, i.e., the breach event.

In short, the diagnosis of viral infections by culture relies on taking care in the collection and storage of specimens, and

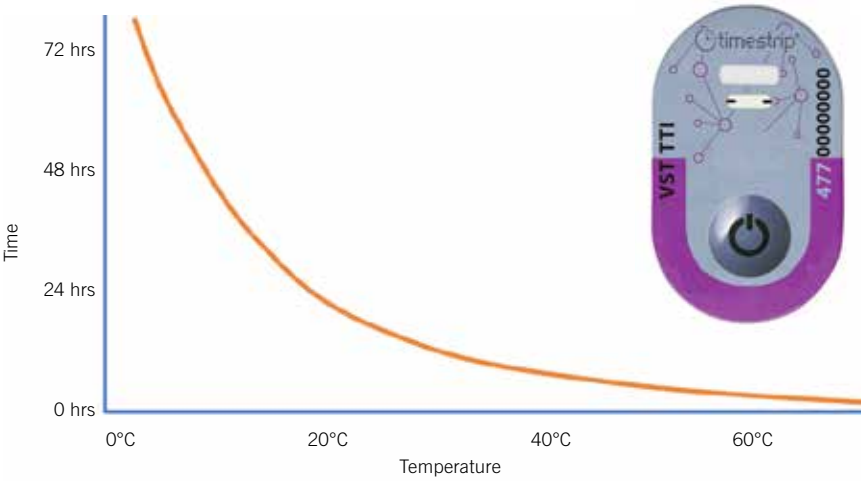


Figure 1: Temperature/time curve for coronavirus

use of a monitored temperature-controlled transport system is required to ensure meaningful test results.

Sterilisation Practices

As part of the measures to control the spread of coronavirus, many organisations, from hospitals to the local pharmacist, are tightening up procedures that involve touching surfaces.

As a response to this risk, sanitisers and sterilisation products, such as wipes and solutions, are increasingly being put to use. However, sterilising solutions will only achieve maximum efficacy while still fresh, and must be used within a specified period after being opened. Time indicators can be a valuable part of the battle here, serving to support best hygiene and safety practice, and ensuring compliance with regulations.

Personal Protective Equipment

There has, of course, been a greatly increased demand for personal protective equipment in recent months. Products with finite lifetimes include face mask filters, cannulas, and IV feeds, as well as many chemicals such as hand sanitisers. Healthcare workers need confirmation that supplies are not past their stated expiration dates.

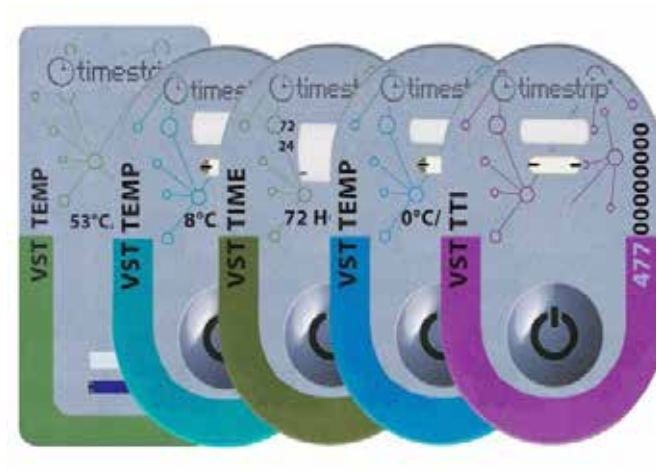
Vaccine Indicators

Specially developed 'smart indicator' technology is being adopted in developing countries where missed vaccinations are common. In one project for the Trust for Vaccines and Immunization, a not-for-profit organisation, this technology has been used to create a set of vaccine indicator reminder bands that are worn by newborn babies to prompt mothers when vaccinations are due. In Pakistan, for example, over the first 14 weeks of a baby's life, four sets of vaccines are advised, yet estimates suggest that up to 60% of infants do not complete the immunisation schedule.

The operation of the devices is based on predictable chemical processes, so no moving parts or electronics are involved – providing a simple, failsafe operation that is very easy to use. The bands are activated by pressing on them lightly. An irreversible process, based on a special food grade dye, then provides a highly visible countdown to the next vaccine due date. Three different colour bands are used: at birth, and at the 6, 10, and 14 weeks' immunisation schedule. Once the infants receive the fourth dose of vaccines, they are protected against nine vaccine-preventable diseases, ensuring their survival and protection from lifelong disability.

Many other healthcare applications exist where item level monitoring in transport and storage is important: biological specimens, diagnostic substances, drugs, blood products, implants, ophthalmic solutions, intraocular lenses,

Vaccine reminder wrist band/anklet



A range of sealed liquid-based indicators designed for virus specimen monitoring

foodstuffs, and laboratory chemicals. In one example, a hospital used a temperature indicator label to monitor their total parenteral nutrition bags to confirm that the bag had not suffered a temperature breach before use, allowing unused product to be returned to the pharmacy for re-issue.

Electronic Temperature Breach Indicators

An electronic alternative to the liquid-based self-adhesive indicators discussed above has recently emerged that promises to offer the best of both worlds. These combine the convenience and cost effectiveness of liquid-sealed indicators with data gathering and auditing capability.

Electronic indicator on box

Electronic temperature indicators, such as 'temperature indication and report' products, are single-use devices, activated by breaking a tab. The stored data cannot be overwritten, providing a guarantee that a temperature breach has not occurred. The durable indicators are fabricated in a metal housing around 28 mm by 26 mm in size and just 2.8 mm thick, so they can be fixed onto many individual product packages. Accuracy is quoted as +/-1.0°C between -30°C and 70°C, with greater accuracy (0.5°C) in the core range of -10°C to 50°C.

Indicators come sealed with in-built button cells for power. Certified to UN3091, the cells are exempt from DGR declaration. Measurement of temperature is at one minute intervals once activated, and there are six 'alarm' levels which record the date, time, and extent of any temperature breaches. A simple 'traffic light' LED system on the indicators provides users along the supply chain with instant status information: ready, operating, stopped, alarm, etc.

Access to the full data report is achieved using an app, and a report can be downloaded wirelessly using a standard smartphone containing the individual device or product ID along with a variety of statistics that can be integrated with other shipment data. This system is also used to demonstrate compliance with relevant regulations, such as GxP, 21CFR Part 11, NIST and ISO 17025.

The development of electronic temperature indicators opens up a wider range of applications that can be monitored cost-effectively throughout the healthcare sector, for example in pharmaceuticals and other high-value products with temperature-sensitive products.

References

1. *WHO, Laboratory testing for coronavirus disease 2019 (COVID-19) in suspected human cases. Interim Guidance, 2 March 2020*

Nora Murphy is Head of Commercial Operations at **Timestrip**. She has over 15 years' experience working within the technology field serving many highly demanding sectors across the globe. At Timestrip, she supports clients and partners around the world in the healthcare, blood, pharma, food, life science, and manufacturing sectors with technology to reduce waste, save money, and ensure safe transport, storage, and monitoring of goods. Nora has a Bachelor of Engineering (Hons) degree in Electronics and Computer Engineering. Timestrip was recently identified in the 'Top 10 Emerging Technologies of 2019' by *Scientific American* magazine.