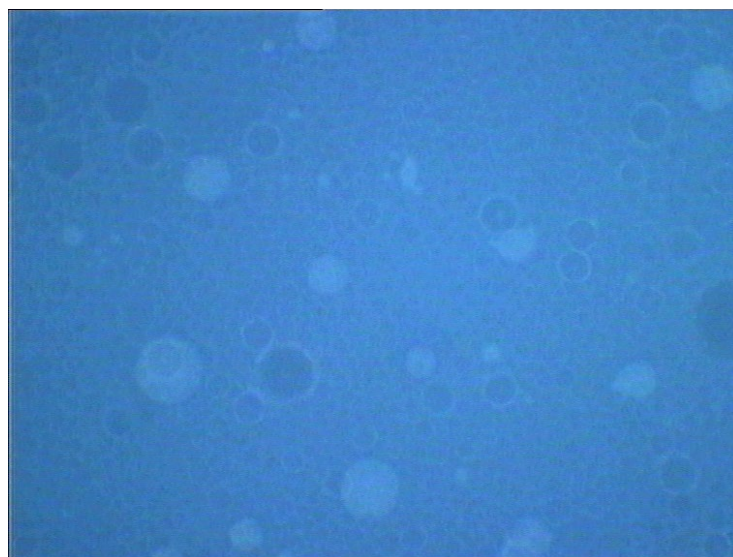


## Rationale for selection of ATR spectrometry in milk measurement

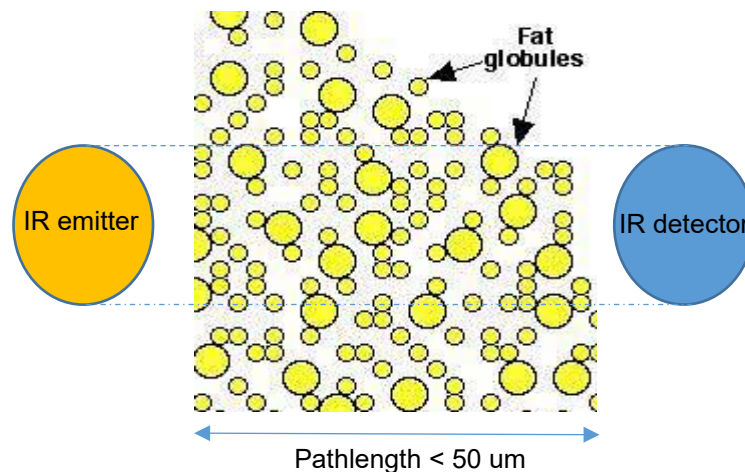
### 1 Measurement of fat in milk

Fat is like oil in water and is immiscible, meaning it will float around within the liquid and may settle to the surface if left stagnant (i.e. cream).



Here's an image of milk we took at 500x mag from our microscope and you can clearly see the bigger circular particles (fat globules) and if you look closely you will also see smaller fat molecules around (notice them overlap - 3D). The fat globule sizes in raw milk are usually normally distributed.

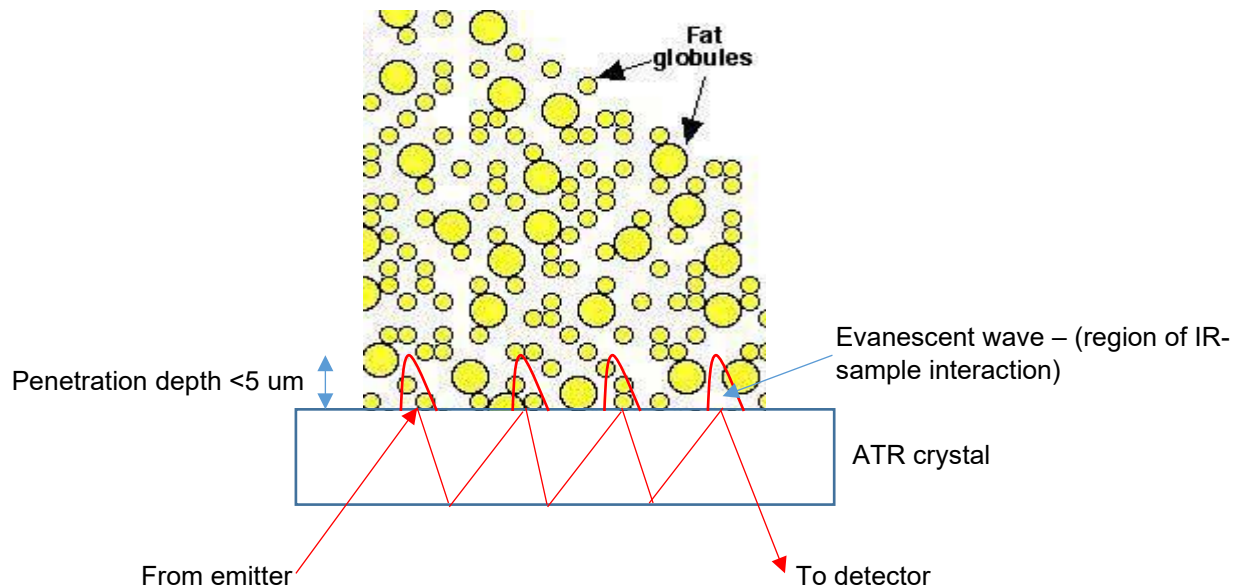
## 2 Measuring milk in transmission



Factors affecting measurement of fat in transmission:

1. Water absorbs a lot of mid-IR which is where the fat peak is, so the detector will receive no light.
2. Need to select an optimum path length which is small enough for the light to pass through and be absorbed fully by water in milk. Therefore, the path length becomes critical and needs to be precise as the absorbance is directly proportional to path length.
3. If the fat globule is  $> 5\mu\text{m}$  light will bounce back and the sample will absorb nothing (like a wall) – this is called the scattering effect and is more prominent in transmission.
4. To solve the water absorption issue, it would require a very powerful IR source (filament type) which will need to be pulsed or chopped. A chopper makes the system big and prone to errors in the long run, as there are more moving parts and no powerful pulsed IR sources for this issue at the moment.
5. A homogenised sample would be required, if not then the complete normal distribution of the fat sample should be present in the IR line of sight during a measurement scan (this is why measurement while flowing can be beneficial).
6. Transmission cells with a small path length  $< 50\mu\text{m}$  can easily get clogged and more difficult to clean – also notice that in transmission there will be two windows that will need cleaning.

## 3 In ATR mode



In the ATR mode, the only region where the IR meets the fat globule is within the evanescent wave and if it is lucky to find the globule in that region, then we would get a representative absorbance measurement from it. So, the following factors will affect the fat absorbance in ATR mode:

1. Effective penetration depth (number of bounces in the ATR crystal times penetration depth).
2. No dependence of a strict path length like in transmission, as this is set by the refractive index of milk and crystal which does not change significantly with seasons or temperatures.
3. Homogeneity of sample (approximate sample size < 5 um but all should be the same size), if not then the complete normal distribution of the fat sample is present in the evanescent wave bounce during a measurement scan (this is why we looked at flow when measuring here).
4. Less scattering effect in ATR compared to transmission.
5. Does not need a very powerful pulsed IR source compared to transmission.
6. ATR crystal will need to be very clean.

We have demonstrated in laboratory conditions point 4 above in both instances: measuring fat accurately in homogenised milk and are working around ways to measure unhomogenized milk when flowing to the desired accuracy.

## 4 Pyreos products and support

Pyreos Linear Arrays are available in 2.5-5.0µm and 5.5-11.0µm wavelength ranges, and with high pass filters for user-selected optical filtering. These can also include extra discrete detectors for higher SNR inspection of pre-defined wavelengths. See [www.pyreos.com/linear-arrays](http://www.pyreos.com/linear-arrays) These can be used in all spectrometry modes described in this paper.

## **AN128 Application Note: Rationale for selection of ATR spectrometry in milk measurement filters**

---

Pyreos analogue or digital TO39 or surface mount packages can also be used to apply higher SNR detection to discrete wavelengths. See <https://pyreos.com/ir-to-39-detectors> and <https://pyreos.com/digital-smd-ir-detectors>

Other white papers and application notes are available at <https://pyreos.com/resource-centre> and case-studies and references are at <https://pyreos.com/case-studies>.

Or contact [sales@pyreos.com](mailto:sales@pyreos.com)