



Dekati® Accessory

SUBSTRATES AND FILTERS FOR DEKATI® IMPACTORS VER6.3

Introduction

Dekati® impactors can be used to measure particle size distributions in the size range of 0-10 µm. Impactors are instruments where particles are size classified and collected, and the collected samples later analysed either gravimetrically or chemically. Depending on the used analysis method, different collection substrates can be used. The same applies also to the ELPI®/ELPI®+ (Electrical Low Pressure Impactor) which is a real-time measurement instrument based on impactor technique. However, ELPI®/ELPI®+ measurement does not require analysis of the particles after the measurement, and in its case the substrates serve another purpose.

The collection *substrates* are placed on each impactor collection plate, in each impactor stage. The number of these plates depends on the type of impactor that is used. In addition, a back-up *filter*, the filter stage accessory, can be used in Dekati® impactors. This back-up filter collects all the particles that pass through the impactor stages, and thus extends the impactor measurement range down to smaller particle sizes. In most cases, the filters used in the filter stage have different properties than the substrates used in the impactor collection plates.

Dekati® impactor line consists of six different impactors; ELPI®+ impactor, ELPI® impactor, DLPI (Dekati® Low Pressure Impactor), DLPI+, DGI (Dekati® Gravimetric Impactor) and Dekati® PM10 impactor. The number of substrates needed for each impactor type for one impactor loading, as well as the filter stage option is presented in Table 1.

Table 1. Substrates and filters for Dekati® impactors.

Impactor type	Substrates/pcs	Filter stage option
ELPI®+	14	Included
ELPI®	13	Code: ELA-650
DLPI+	14	Not available
DLPI	13	Code: IA-208
DGI	4	Included
PM10	3	Included

Collection substrates

Collection substrates are used in the impactor stages, and they are of different size than the backup filter used in the filter stage. The collection substrates are placed on the impactor collection plate prior to the measurement, and removed after for analysis. Figure 1 shows the collection plate of a Dekati® ELPI®, DLPI or PM10 impactor. The size of the collection substrates in ELPI®+, ELPI®, DLPI, DLPI+ and Dekati® PM10 impactor is 25 mm in diameter, for DGI they are 47 mm.

Figure 1. A Collection plate of a Dekati® ELPI®, DLPI or PM10 impactor with an aluminium foil as a collection substrate.



The collection substrates used in impactors should be thin and have a smooth surface to prevent changes in the impactor collection efficiencies and cut-points. The substrate material needs to be chosen also in consideration of the measurement conditions (e.g. temperature), and used particle analysis methods.

Aluminium

Perhaps the most widely used impactor substrate material in gravimetric measurements is aluminium foil. The advantages of aluminium foil are that it is very thin, the surface is smooth, it is cheap and easy to handle (the foils can be made of household aluminium foil). Disadvantages are that only limited type of chemical analysis can be performed from the (pre-prepared) aluminium foil, and the hardness of the metal surfaces does not limit particle bounce.

Greasing of the collection substrates

Particle bounce occurs especially when the sampled particles are solid and dry. The particles hit the collection surface with high velocity and simply bounce off from the 'correct' impactor stage into the following stage. The bounce effect can be reduced or even prevented by surface coating, which is recommended always when using aluminium foils or other hard surface as collection media. The hard collection substrate is coated with a sticky substance resulting in improved collection efficiency and more accurate results. When selecting the appropriate substance for surface coating, the mass stability and chemical composition, viscosity, purity and stability of the substance need to be considered. Especially in low-pressure impactors the substance need to be stable also in absolute pressures of about 100 mbar.

A commonly used substrate coating substance in impactor measurements is Apiezon-L grease. The Apiezon-L grease is chemically pure, it has high enough viscosity to stay on the collection plate, and it does not volatilise even at 100 mbar. The layer of grease applied on the collection substrate has to be thin and smooth, which is why the grease needs to be dissolved into a suitable solvent before applying it on a foil. Apiezon-L can be dissolved e.g. in carbon tetra-chloride, toluene or acetone. The solution of the grease and solvent is then spread, painted with e.g. a fine brush or sprayed on the collection substrate resulting in a thin and smooth film. After the greasing the solvent has to be let to volatilise completely off the substrates. Baking the foils after greasing may also be required to achieve weight stability.

Apiezon-H for high temperature measurements

Impactor measurements are sometimes made in higher temperatures than 100 °C that the Apiezon-L grease can endure. For high temperature applications Dekati provides Apiezon-H grease. The Apiezon-H grease endures temperatures up to 200 °C that is also the upper temperature limit for the heated ELPI®, DLPI, DLPI+ (max 180 °C), High Temperature ELPI®+ (max 180 °C) and Dekati® PM10 impactor setups. The Apiezon-H grease is widely used in different applications and is silicone free. The grease can be

used in low to medium vacuum ranges so it is suitable to be used in the Dekati® Impactors.

The Apiezon-H grease absorbs chemical impurities from metal surfaces which has to be taken into account if chemical analysis on the collected samples is performed. The Apiezon-H grease is used in the same way as the Apiezon-L; first the grease is dissolved in suitable solvent and then applied on the impactor collection substrates. Suitable solvents for Apiezon-H grease are for example carbon tetrachloride and toluene, Apiezon-H does not dissolve properly in acetone.

Collection substrate spray

An easy and time-saving way of greasing the collection substrates is to use a spray. Dekati provides a spray for this purpose, the Dekati® Collection Substrate Spray DS-515. The DS-515 consists of Apiezon-L in a solvent and it is applied on the substrates by using a stencil to cover the edges of the substrates. More detailed instructions on the use of DS-515 can be found in the DS-515 Instruction manual provided with the spray. Table 2 presents the aluminium foils, coating grease and related accessories provided by Dekati Ltd.



Figure 2. Using Dekati® Collection Substrate Spray to grease aluminium foils placed in a stencil.

Table 2. Aluminium foils and substrate greases provided by Dekati.

Product code	Product	Suitable for impactor	Package size	Diameter/mm	Max Temp/°C
CF-300	Aluminium foil	ELPI®, ELPI+, DLPI, DLPI+, PM10	300	25	
CFG-225	Greased aluminium foil	ELPI®, ELPI+, DLPI, DLPI+, PM10	100	25	100
CF-301	Aluminium foil	DGI	300	47	
CFG-147	Greased aluminium foil	DGI	100	47	150
AG-10	Apiezon-L grease	ELPI®, ELPI+, DLPI, DLPI+, PM10, DGI	1		100
AG-25	Apiezon-H grease	ELPI®, ELPI+, DLPI, DLPI+, PM10, DGI	1		200
DS-515	Apiezon-L grease spray	ELPI®, ELPI+, DLPI, DLPI+, PM10, DGI	1		100
DS-125	Stencil, 25mm	ELPI®, ELPI+, DLPI, DLPI+, PM10	1	15x25	

Polycarbonate foils for chemical analysis

Since the aluminium foil is not suitable for many types of chemical analyses, different types of substrates may need to be used. The choice of a suitable collection material for chemical analysis depends on the used analysis method. Polycarbonate and Teflon membranes are well suited for most commonly used methods, but other type of substrates can be used as well. The requirements are, as stated earlier, thin and smooth surface. In addition, the material should not have any size of pores since the sample flow can penetrate through these holes and part of the sample therefore stays on the substrate material and the metal collection plate.

Dekati provides polycarbonate membranes for ELPI[®]+, ELPI[®], DLPI, DLPI+ and Dekati[®] PM10 impactors. These membranes are the non-porous type and therefore suitable even for high-flow-rate impactors. Table 3 presents details of the polycarbonate foils.

Table 4. Collection substrates for chemical analysis.

Product code	Product	Suitable for impactor	Package size	Diameter/ mm	Max. Temp./ °C
IPR-200	Polycarbonate foil	ELPI [®] +, ELPI [®] , DLPI, DLPI+, Dekati [®] PM10	100	25	140

Collection filters

In Dekati[®] impactors collection filters are used in the back-up filter stage. In DLPI, ELPI[®] and Dekati[®] PM10 impactors, the filters are 47 mm in diameter, in DGI 70 mm. In the ELPI[®]+ the filter stage filter is fixed in the stage itself and it cannot be replaced.

The selection of the most suitable filter material requires consideration of few different things than when selecting collection substrates. Again, the maximum temperature as well as the analysis method need to be considered, but also the collection efficiency of the filter material for submicron particles and the pressure drop of the filter have to be taken into account.

The filter stage in Dekati[®] impactors is placed under the first stage of the standard impactor assembly. In low-pressure impactors (ELPI[®], DLPI) the flow is controlled by adjusting 100 mbar below the first stage of the impactor. With filter stage, this means 100 mbar above the filter. All filter materials resist the flow somewhat, and if the pump is not efficient enough 100 mbar cannot be reached above the filter due to the filter resistance. In that case a filter with lower resistance of flow/pressure drop or a more efficient pump need to be used.

Dekati has tested few filter-pump combinations, and the functional combinations are listed in Table 5. All these filters, except the Dekati[®] Low Pressure Drop Filter, can be used with the Dekati[®] PM10 impactor as well. For DGI filter stage 70 mm filters need to be used. Dekati provides the Emfab, TX40 filters for this purpose.

Table 5. Recommended filter-pump combinations with different ELPI®/DLPI impactor flow rates.

Filter/Impactor flow rate	10 lpm	30 lpm
A/D glass fiber*	DP25, DP65	
TEFLO™ 3 µm*	DP25, DP65	DP65
TEFLO™ 2 µm	DP25, DP65	
Emfab, TX40HI20WW	DP25, DP65	
Fluoropore™ 1.0 µm*	DP25, DP65	
Dekati® LPD filter**	DP25, DP65	DP25, DP65

*Not provided by Dekati Ltd.

** Suitable only for use with ELPI®, not DLPI.

DP25 is Leybold Sogevac SV25 pump.

DP65 is Leybold Sogevac SV65 pump.

Other type of filters can be used on the filter stage as well, and the suitability can be tested by trying to adjust 100 mbar above the filter. If this cannot be achieved, a bigger pump is required, or another type of filter should be used. In addition, the collection efficiency of the filter needs to be taken into account. Some information on the filters provided by Dekati Ltd is listed in Table 6.

Table 6. Filters provided by Dekati Ltd.

Product number	Product name	Filter material	Package size/pcs	Diameter/mm	Max. temp/°C
PMT-247	Teflon filter	PTFE with PMP	50	47	200
PMF-047	EMFAB filter, TX40	Borosilicate microfibers reinforced with woven glass cloth and bonded with PTFE	100	47	260
PMF-370	EMFAB filter, TX40	Borosilicate microfibers reinforced with woven glass cloth and bonded with PTFE	100	70	260
ELA-652	Low Pressure Drop filter	Glass fiber, silicon, stainless steel	1	47(for ELPI® only)	200

Dekati Ltd will take no responsibility whatsoever over the quality changes of the filters caused by the filter manufacturers.

Balance

In gravimetric impactor measurements the accuracy of the micro-balance that is used for weighing has to be considered. The weight of one 25 mm aluminium substrate is about 15–25 mg, the 47 mm substrate (DGI) weighs about 95 mg. In low concentration measurements, such as ambient air measurements, an accuracy of about 1 µg is desirable especially if collection times are short. In high concentration measurements 10 µg accuracy is usually acceptable.

Discussion

Different types of substrates can be used as collection media in impactor measurements keeping in mind few requirements; the collection substrate has to be thin and smooth not to affect the impactor operation, and preferably greased to prevent bouncing effects. Even with a coated substrates, bounce can occur when the impaction surface becomes sufficiently loaded with particles. In this case the incoming particles don't hit the grease layer anymore but already collected particles instead. Another problem that may occur is when too much particles are collected on the collection plate. Since the gas flow velocity inside the impactor is high, this can result in so called blow-off effect when the excess particles are blown off from the collection surface. This effect

can also happen with grease if too much of it is applied on the collection surface. These effects can be avoided by using a porous sintered metal plate saturated with oil, but this solution is only applicable to ELPI[®] and ELPI[®]+ since the porous metal plate is extremely difficult to analyse afterwards.

Thick, fibrous filters are not recommended to be used in impactor stages both because some of the sample flow goes through this medium filtering the smaller particles, and particles may bounce off from the fibres. In addition, the fibrous material has effect on the collection efficiency curves of the impactor. Some substrate materials may also react with the sample gas resulting in weight gain though no particles are present. The only way of checking this effect is by running blanks, i.e. running a normal impactor measurement with a particle filter at the impactor inlet.

Whatever the substrate material and its collection efficiency, all the collection substrates need to be changed or cleaned every now and then. How often, depends on the collected particle type. However, as rule of thumb, a maximum loading on one Dekati[®] PM Impactor/DLPI/DLPI+/ELPI[®]/ELPI[®]+ stage can be said to be 1 mg. For DGI Impactor the maximum loading is about 10 mg.

References

Calvert, S. & Englund, H.M. Handbook of Air Pollution Technology. 1984. John Wiley & Sons.

Dekati Ltd. 2003. Technical note. Dekati[®] Collection Substrate Spray DS-515.

Dekati Ltd. 2003. Technical note. Dekati[®] Low Pressure Drop filter, ELA-652.

Hinds, W.C. Aerosol Technology –Properties, behavior, and measurement of airborne particles. Second Edition. 1999. John Wiley & Sons, Inc.

van Gulijk, C., Marijnissen, J., Makkee, M. & Moulijn, J. 2003. Oil-soaked sintered impactors for the ELPI in diesel particulate measurements. Journal of Aerosol science, vol 32, pp. 635-640.

Willeke, K. & Baron, P.A. Aerosol Measurement. Principles, Techniques and Applications. 1993. Van Nostrand Reinhold.

For further information, please contact support@dekati.fi