Enzyme Substrates

Discover our unrivalled range of ***oligosaccharide*** *and* ***polysaccharide*** *products researched, developed and supplied exclusively by Megazyme*

NEOGEN | Megazyme

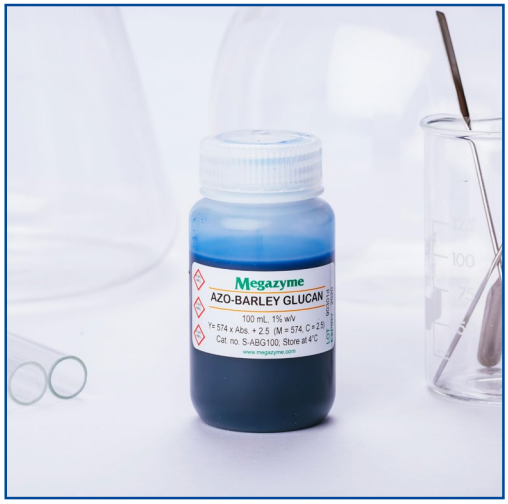
Contents

The importance of enzymes in industrial processes and scientific research is constantly growing and the measurement of enzyme activity is of paramount importance for the use and characterisation of enzyme preparations.

Megazyme has unrivalled expertise in the production of pure enzymes and of substrates for the measurement of enzymatic activity. Our wide range of diverse enzymatic substrates can be classified in three categories:

1. Dyed Polysaccharides

Introduction to Dyed Polysaccharides



Dyed polysaccharides are useful substrates for the specific measurement of *endo*-acting hydrolases activity in crude plant extracts or industrial enzyme preparations.

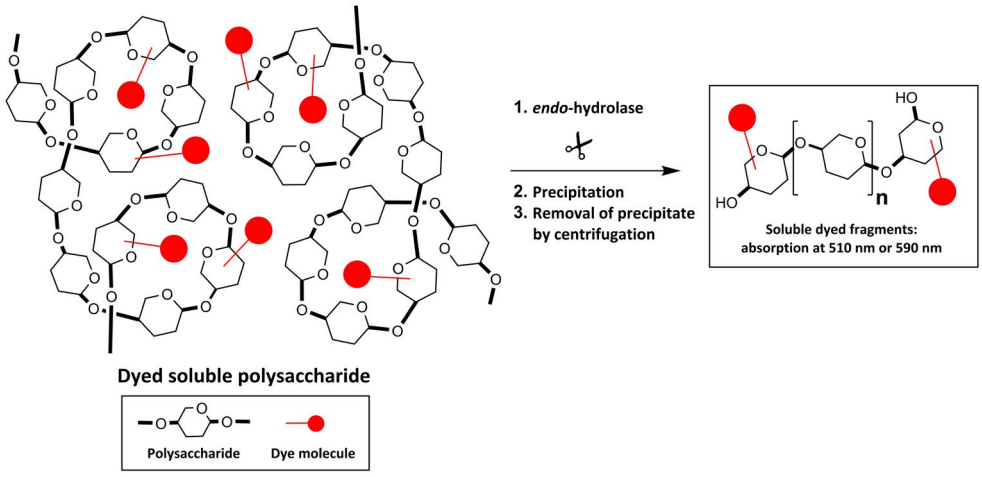
In dyed polysaccharides, dye molecules are covalently attached to a polysaccharide or a partially depolymerised polysaccharide, to obtain substrates that are supplied either as a powder or in liquid form.

The *endo*-acting hydrolase enzymes that recognise and act on these substrates release dyed fragments to an extent which is proportional to their enzymatic activity and which can be calculated by converting the absorbance obtained using a standard curve provided.

Dyed polysaccharide substrates offer the advantages of being specific and sensitive, and can form the basis of accurate, reliable and robust assay procedures, although they are not readily suited to automated assays due to a filtration or centrifugation step included in the assay protocol.

a) Soluble dyed substrates

Key features of Megazyme's soluble dyed substrates



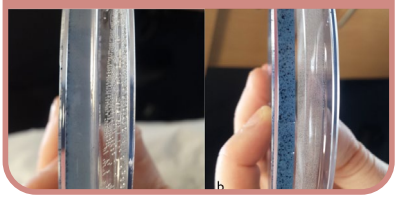
- ✓ Suitable for analysis of crude enzyme extracts
- ✓ Suitable for analysis of purified enzymes
- ✓ Quantitative assay
- ✓ Suitable for gel/agar plate activity screening
- ✓ Suitable for *endo*-acting enzymes
- × Chemically defined substrate
- × Suitable for automation
- × Suitable for *exo*-acting enzymes

a) Soluble Dyed Substrates

Assay procedure for soluble dyed substrates

1. The substrate is water soluble and is readily recognised and hydrolysed by an *endo*-acting hydrolase.
2. The reaction is terminated by the addition of a precipitant solution (e.g. ethanol) wherein high molecular weight, partially hydrolysed substrate fragments precipitate from solution.
3. The suspension is mixed thoroughly, centrifuged and the colour in the solution is measured using a spectrophotometer.
4. The enzymatic activity is determined using a standard curve provided.

The use of agar plates containing 0.5% w/v xanthan gum avoids settling of the insoluble dyed substrates



Our range of soluble dyed substrates

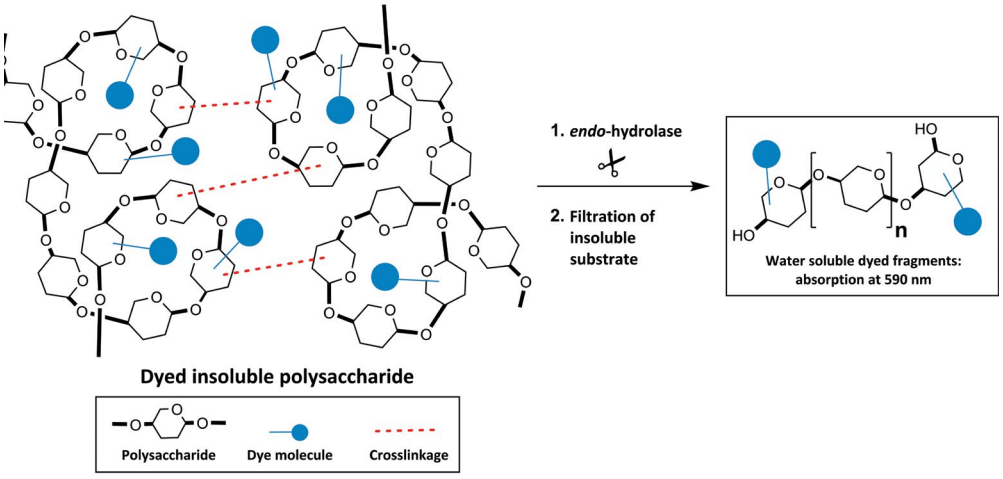
Product Name	Product Code	Enzyme Measured
Red Starch	S-RSTAR	α-Amylase
Red Debranched Arabinan (sugar beet)	S-RDAR	*endo*-1,5-α-Arabinanase
Azo-CM-Cellulose (liquid)	S-ACMCL	*endo*-Cellulase / *endo*-1,4-β-Glucanase
Azo-CM-Cellulose (powder)	S-ACMC	
Azo-Barley Glucan	S-ABG100	Lichenase / *endo*-β-Glucanase
Red Pullulan	S-RPUL	Pullulanase / Limit-dextrinase
Azo-Carob Galactomannan	S-ACGLM	*endo*-1,4-β-Mannanase
Azo-Galactan (potato)	S-AGALP	*endo*-1,4-β-Galactanase
Azocasein	S-AZCAS	*endo*-Protease
Azo-Wheat Arabinoxylan (liquid)	S-AWAXL	*endo*-1,4-β-Xylanase
Azo-Wheat Arabinoxylan (powder)	S-AWAXP	
Azo-Xylan (birchwood) (liquid)	S-AXBL	
Azo-Xylan (birchwood) (powder)	S-AXBP	

b) Insoluble Dyed Substrates

Megazyme's insoluble dyed substrates are prepared by dyeing and crosslinking soluble polysaccharides.

These substrates are provided in both granular and fine particle size. The finely milled substrates are more useful in agar plate assays and semi quantitative tube and plate assays. Substrates in other colours are also being developed for gel/agar plate activity screenings.

Insoluble chromogenic substrates are recommended for semi-quantitative assays.



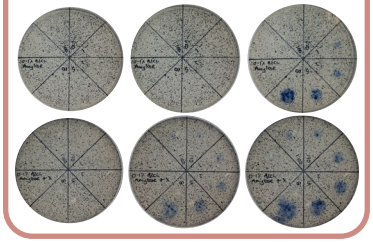
Key features of Megazyme's insoluble dyed substrates

- ✓ Suitable for analysis of crude enzyme extracts
- ✓ Suitable for analysis of purified enzymes
- ✓ Suitable for gel/agar plate activity screening
- ✓ Suitable for *endo*-acting enzymes
- × Quantitative assay
- × Chemically defined substrate
- × Suitable for automation
- × Suitable for *exo*-acting enzymes

Assay procedure for insoluble dyed substrates

1. The hydrated insoluble substrate forms gelatinous particles which are readily recognised and hydrolysed by an *endo*-acting hydrolase. The partial hydrolysis of insoluble chromogenic substrates releases water soluble dyed substrate fragments.
2. The reaction is terminated by adding an alkaline solution to stop enzyme activity and the reaction slurry is filtered or centrifuged.
3. The colour released in solution is measured using a spectrophotometer and the colour intensity is directly related to enzyme activity.

The use of insoluble dyed substrates in agar plates containing 0.5% w/v xanthan gum allows enzymatic activity detection more rapidly and at lower enzyme concentration



b) Insoluble Dyed Substrates

Our range of insoluble dyed substrates

Product Name	Product Code	Enzyme Measured
AZCL-HE-Cellulose	I-AZCEL	*endo*-Cellulase

c) Tablet Substrates

Megazyme supplies a range of enzyme tablet tests for ultimate end-user convenience. The insoluble chromogenic substrates discussed above are formulated into tablets. By using tablet tests, it is possible to obtain quantitative determinations of *endo*-acting hydrolase activities.

From a procedural perspective, tablet tests operate in the same way as assays using insoluble chromogenic substrates. The advantage of enzyme tablet tests is that the need to accurately weigh substrate quantities (and the error associated with this parameter) is removed.

Key features of Megazyme's tablet substrates

- ✓ Suitable for analysis of crude enzyme extracts
- ✓ Suitable for analysis of purified enzymes
- ✓ Quantitative assay
- ✓ Suitable for *endo*-acting enzymes
- × Chemically defined substrate
- × Suitable for automation
- × Suitable for gel/agar plate activity screening
- × Suitable for *exo*-acting enzymes

Our range of tablet substrates

Product Name	Product Code	Enzyme Measured
Amylazyme	T-AMZ	α-Amylase
Amylazyme HY	T-AMZHY	
Arabinazyme	T-ARZ	*endo*-1,5-α-Arabinanase
Cellazyme C (60 mg)	T-CCZ	*endo*-Cellulase / *endo*-1,4-B-Glucanase
Cellazyme T	T-CTZ	
Chitozyme	T-CHZ	*endo*-Chitosanase
α-Dextrazyme	T-DEXT	*endo*-1,6-α-Dextranase
β-Glucazyme	T-BGZ	Lichenase / *endo*-β-Glucanase
Galactazyme	T-GLZ	*endo*-1,4-β-Galactanase
1,3-β-Glucazyme HS	T-CUR	*endo*-1,3-β-Glucanase
Limit-Dextrizyme	T-LDZ	Pullulanase / Limit-dextrinase
Mannazyme	T-MNZ	*endo*-1,4-β-Mannanase
Protazyme AK	T-PRAK	*endo*-Protease
Protazyme OL	T-PROL	
Xylazyme AX (60 mg)	T-XAX	*endo*-1,4-β-Xylanase
Xylazyme (100 mg)	T-XYZ	

2. Colourimetric Oligosaccharides

Introduction to Colourimetric Oligosaccharides

Colourimetric substrates are useful for the specific measurement of *endo*-acting and *exo*-acting carbohydrate hydrolase activity. The molecular structure of these substrates is chemically-defined which completely removes the possibility of any 'batch to batch' variability.

These substrates are prepared by installing a covalently bound colourimetric or fluorometric moiety onto the reducing end sugar residue of an oligosaccharide and are usually supplied as a fine powder or as a solution. The *endo*- or *exo*-acting hydrolase enzymes that recognise and cleave these substrates, together with a specific glycosidase enzyme, release the colourimetric or fluorometric moiety to an extent which is proportional to their enzymatic activity and which can easily be calculated using the applicable extinction coefficient.

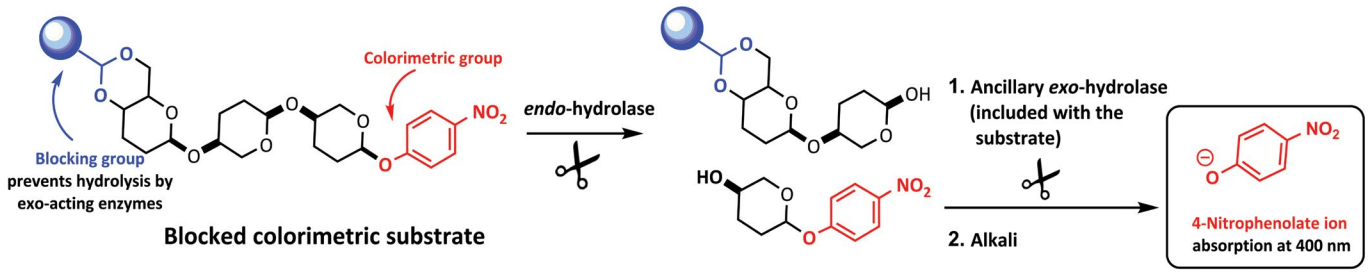
Colourimetric oligosaccharides offer the advantages of being **specific** and **sensitive**, and can be used in **fully automated assay formats** owing to the fact that there is no filtration step required in these assays. Assay formats based on these substrates are the most convenient for the user and display the highest levels of **reproducibility**.

a) Blocked Oligosaccharides

Blocked colourimetric substrates for the measurement of carbohydrate hydrolase activity are **exclusively offered by Megazyme** and are an excellent alternative to dyed polysaccharides for the quantitative measurement of *endo*-acting hydrolase activity in crude enzyme preparations.

No variability between substrate batches occurs due to the chemically-defined molecular structures of these substances. These substrates are usually available as components within assay kits and are used in enzyme-coupled assay protocols.

The blocking group at the non-reducing end of the substrate prevents the activity of *exo*-acting enzymes present in a crude mixture and their structure makes them absolutely specific targets for the *endo*-acting enzyme being analysed.



Key features of Megazyme's blocked oligosaccharides

- ✓ Suitable for analysis of crude enzyme extracts
- ✓ Suitable for analysis of purified enzymes
- ✓ Chemically defined substrate
- ✓ Quantitative assay
- ✓ Suitable for automation
- ✓ Suitable for *endo*-acting enzymes
- × Suitable for gel/agar plate activity screening
- × Suitable for *exo*-acting enzymes

a) Blocked Oligosaccharides

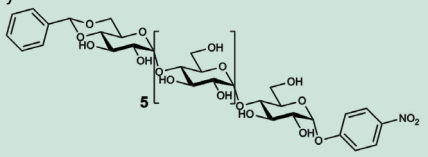
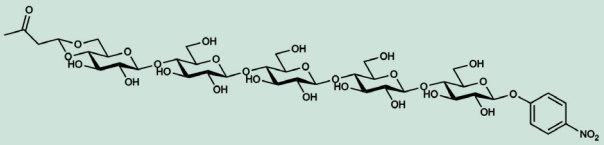
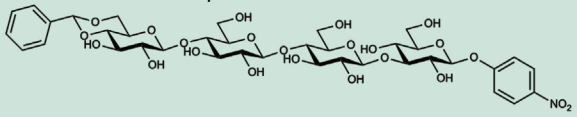
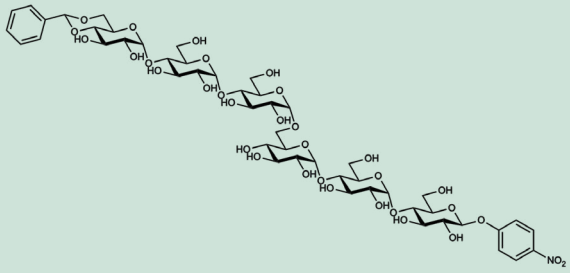
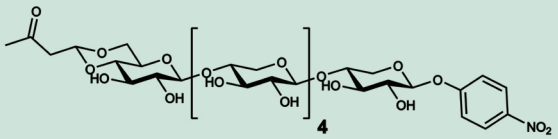
Assay procedure for blocked oligosaccharides

1. The soluble blocked colourimetric substrate is readily recognised and hydrolysed by an *endo*-acting hydrolase. The hydrolysis of the substrate releases two components in solution and the ancillary *exo*-acting enzyme provided is then able to further hydrolyse the fragment bearing the colourimetric group to release this colourimetric group into solution (e.g. 4-nitrophenol).

2. The reaction is terminated by adding an alkaline solution to stop enzyme activity.

3. The colour release in solution is measured using a spectrophotometer and the colour intensity is directly related to enzyme activity.

Our range of blocked oligosaccharides

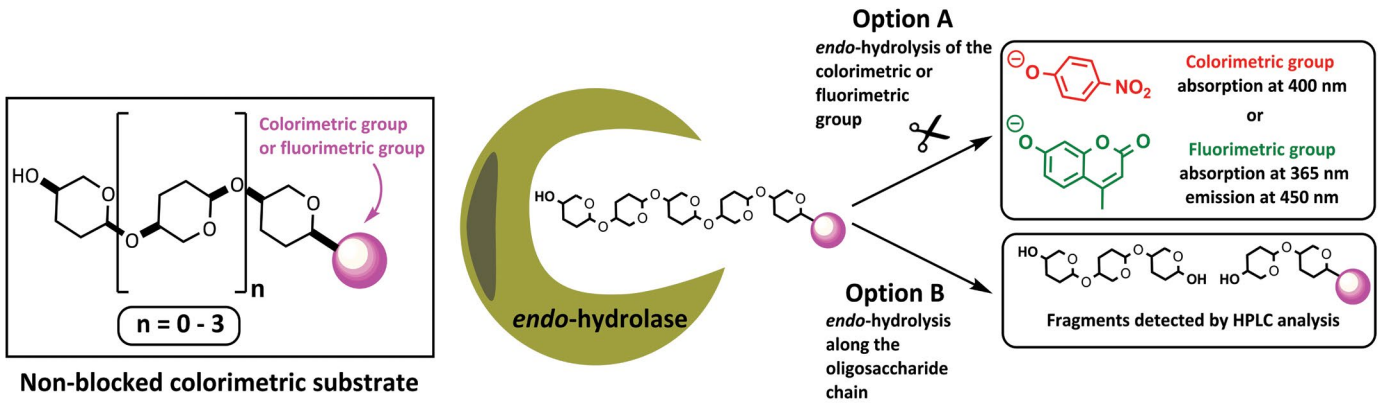
Product Name	Product Code	Enzyme Measured
α-Amylase Assay Kit (Ceralpha method)	K-CERA	α-Amylase 
α-Amylase SD Assay Kit	K-AMYLSD	
α-Amylase Reagent (Ceralpha)	R-CAAR4	
Amylase HR Reagent	R-AMHR4	
Cellulase Assay Kit (CellG5 method)	K-CellG5	Cellulase / *endo*-1,4-β-Glucanase 
Malt β-Glucanase / Lichenase Assay Kit (MBG4 method)	K-MBG4	Lichenase / *endo*-β-Glucanase 
Pullulanase / Limit-Dextrinase Assay Kit (PullG6 method)	K-PullG6	Pullanase / Limit-Dextrinase 
Xylanase Assay Kit (XylX6 Method)	K-XylX6	*endo*-1,4-β-Xylanase 

b) Non-Blocked Oligosaccharides

Non-blocked colourimetric substrates are generally used for the quantitative measurement of *endo*-acting hydrolase activity in purified enzyme preparations. The lack of a blocking-group makes these substrates unsuitable for the analysis of crude enzymatic mixtures because of the likely presence of competing *exo* acting enzymes. In non-blocked oligosaccharide substrates, an oligosaccharide chain of defined length is covalently linked to either a colourimetric (4-nitrophenol or 2-chloro-4-nitrophenol) or a fluorometric (4-methylumbelliferone) group.

Purified-acting enzymes have very specific active site requirements. The possibility of screening substrates having different chain length allows for a sensitive and specific characterisation of-acting carbohydrate hydrolases. Researchers can derive valuable information from the increase in absorbance at 400 nm (or lack thereof) or indeed by HPLC analysis of enzyme incubations with colourimetric oligosaccharides of varying length.

The use of fluorometric substrates is similar to that of colourimetric ones from a procedural perspective. They generally display a higher sensitivity, however a fluorimeter is required to measure the release of the fluorometric group in solution.

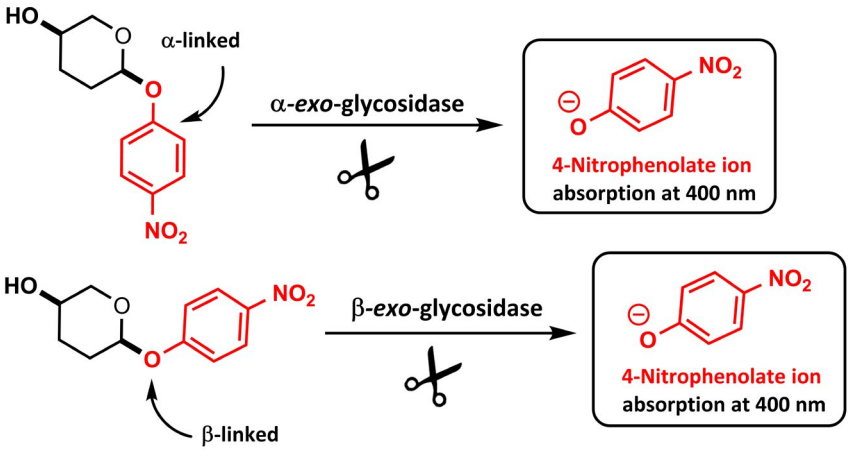


Key features of Megazyme's non-blocked oligosaccharides

- ✓ Suitable for analysis of purified enzymes
- ✓ Chemically defined substrate
- ✓ Quantitative assay
- ✓ Suitable for automation
- ✓ Suitable for *endo*-acting enzymes
- × Suitable for analysis of crude enzyme extracts
- × Suitable for gel/agar plate activity screening
- × Suitable for *exo*-acting enzymes

c) Colourimetric substrates for *exo*-acting carbohydrate hydrolases

Colourimetric monosaccharides are commonly used for the quantitative measurement of *exo*-acting hydrolase activity in either purified or crude enzyme preparations. Colourimetric monosaccharide substrates contain a colourimetric group (4-nitrophenol) either α- or β-linked to a monosaccharide.



Key features of Megazyme's colourimetric substrates for *exo*-acting carbohydrate hydrolases

- ✓ Suitable for analysis of purified enzymes
- ✓ Suitable for analysis of crude enzyme extracts
- ✓ Chemically defined substrate
- ✓ Quantitative assay
- ✓ Suitable for automation
- ✓ Suitable for *exo*-acting enzymes
- × Suitable for gel/agar plate activity screening
- × Suitable for *endo*-acting enzymes

Assay procedure for colourimetric substrates for *exo*-acting carbohydrate hydrolases

1. Once a soluble colourimetric monosaccharide substrate is hydrolysed by an *exo*-acting hydrolase, the colourimetric group is released in solution.
2. The reaction is terminated by adding an alkaline solution to stop enzyme activity and develop colour.
3. The colour release in solution is measured using a spectrophotometer and the colour intensity is directly related to enzyme activity.

c) Colourimetric substrates for *exo*-acting carbohydrate hydrolases

Our range of colourimetric substrates for *exo*-acting carbohydrate hydrolases

Product Name	Product Code	Enzyme Measured
β-Amylase Assay Kit (Betamyl-3) (4-Nitrophenyl-β-maltotrioside + β-glucosidase)	K-BETA3	α-Amylase
β-Amylase Assay Reagent (Betamyl-3) (4-Nitrophenyl-β-maltotrioside + β-glucosidase)	R-BAMR3	
Amyloglucosidase Assay Reagent (4-Nitrophenyl-β-maltoside + β-glucosidase)	R-AMGR3	Amyloglucosidase
4-Nitrophenyl-α-L-arabinofuranoside	O-PNPAF	α-Arabinofuranosidase

3. Carbohydrates

Introduction to Carbohydrates

Megazyme offers a broad range of carbohydrates for scientists involved in enzyme research, acting as the **sole global supplier** for a number of unique carbohydrates.

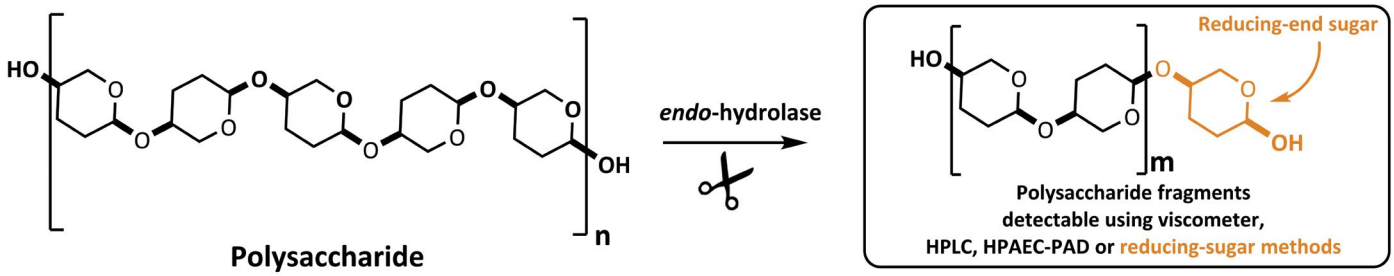
Our **best-in-class purity** and reputation for quality have resulted in longstanding relationships with some of the foremost research institutes in the world.

While dyed polysaccharide and colourimetric oligosaccharide-based assays are certainly the most convenient methods for the assay of hydrolytic enzymes, polysaccharides and oligosaccharides, as the native substrates encountered by carbohydrate hydrolases in nature, can give the truest insight into their mechanism of action, active site requirements, binding affinities and activities.

a) Polysaccharides

Traditionally, *endo*-acting carbohydrate hydrolases have been measured using the native polysaccharide as the enzymatic substrate, followed by quantification of the increase in reducing sugar or decrease in viscosity of the substrate solution on hydrolysis.

Reducing-sugar methods can be used for the assay of pure enzyme solutions but are unsuitable for use with crude enzyme extracts that may already contain reducing sugars. Viscosity reduction methods are specific for *endo*-hydrolase activity but are tedious to perform and require specialist equipment.



Key features of Megazyme's polysaccharides

- ✓ Suitable for analysis of purified enzymes
- ✓ Quantitative assay
- ✓ Suitable for gel/agar plate activity screening
- ✓ Suitable for *endo*-acting enzymes
- × Suitable for analysis of crude enzyme extracts
- × Chemically defined substrate
- × Suitable for automation
- × Suitable for *exo*-acting enzymes

a) Polysaccharides

Our range of polysaccharides

Product	Product Code	Enzyme Activity	
Amylose (potato)	P-AMYL	α-Amylase	
β-Limit Dextrin	P-BLDX		
Arabinan (sugar beet)	P-ARAB	*endo*-1,5-α-Arabinanase	
Xyloglucan (tamarind)	P-XYGLN	*endo*-Cellulase / *endo*-1,4-β-Glucanase	
Glucomannan (konjac; low viscosity)	P-GLCML		
Levan	P-LEVAN	*endo*-Levanase	*endo*-Fructanase
Galactan (potato)	P-GALPOT	*endo*-1,4-β-Galactanase	
Lichenan (Icelandic moss)	P-LICHN	Lichenase / *endo*-β-Glucanase	
β-Glucan MW standard	P-MWBGS		
β-Glucan (barley; low viscosity)	P-BGBL		
β-Glucan (barley; medium viscosity)	P-BGBM		
β-Glucan (barley; high viscosity)	P-BGBH		
β-Glucan (oat; medium viscosity)	P-BGOM		
β-Glucan CFA standard	P-BGCFA		
1,3-alpha-Glucan (Mutan)	P-AGLU13		
CM-Curdlan	P-CMCUR	*endo*-1,3-β-Glucanase	
β-Glucan (yeast; alkali soluble)	P-BGYST		

a) Polysaccharides

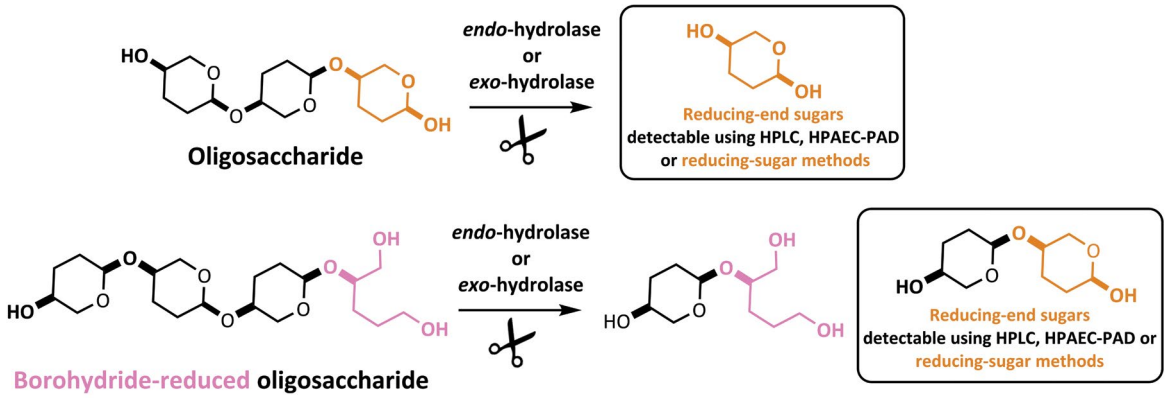
Product	Product Code	Enzyme Activity	
1,2-β-Glucan	P-BGLU12	*endo*-1,2-β-Glucanase	
Mannan (ivory nut)	P-MANIV	*endo*-1,4-β-Mannanase	
Mannan (1,4-β-D-mannan)	P-MANCB		
Galactomannan (carob; low viscosity)	P-GALML		
Polygalacturonic Acid (from citrus pectin)	P-PGACIT	Polygalacturonic Acid (from citrus pectin)	
Rhamnogalacturonan I (potato)	P-RHAM1	Rhamnogalacturonan hydrolase / lyase	
Rhamnogalacturonan (soy bean)	P-RHAGN		
Xylan (beechwood)	P-XYLNBE	*endo*-1,4-β-Xylanase	
Arabinoxylan (rye flour)	P-RAXY		
Arabinoxylan (wheat flour; low viscosity)	P-WAXYL		
Arabinoxylan (wheat flour; medium viscosity)	P-WAXYM		
Arabinoxylan (wheat flour; high viscosity)	P-WAXYH		
Arabinoxylan (wheat flour; for reducing sugar assays)	P-WAXYRS		
Arabinoxylan (wheat flour; insoluble)	P-WAXYI		
Xylan (birchwood, partially acetylated)	P-ACXYL	*endo*-1,4-β-Xylanase	Acetylxylan esterase

b) Oligosaccharides

Defined oligosaccharide substrates are particularly useful for researchers in the field of glycoscience. These molecules can be used to help characterise either *endo*- or *exo*-acting carbohydrate hydrolase enzymes, the activity of which can be measured through reducing sugar methods or HPLC/HPAEC-PAD analysis.

A number of borohydride reduced oligosaccharides are also available. These are particularly useful substrates in reducing sugar assays where the native oligosaccharides, themselves being reducing sugars, can produce a high 'blank' absorbance value, thereby reducing the sensitivity of the assay.

Oligosaccharides can also be employed as building blocks for the chemical synthesis of either colourimetric substrates or inhibitors of enzymes of interest.



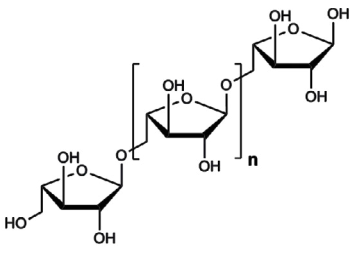
Key features of Megazyme's oligosaccharides

- ✓ Suitable for analysis of purified enzymes
- ✓ Quantitative assay
- ✓ Chemically defined substrate
- ✓ Suitable for *endo*-acting enzymes
- ✓ Suitable for *exo*-acting enzymes
- × Suitable for analysis of crude enzyme extracts
- × Suitable for automation
- × Suitable for gel/agar plate activity screening

1,5-α-L-Arabinooligosaccharides

Substrates for *endo*-1,5-α-arabinanase and α-arabinofuranosidase.

O-ABI	DP2	Arabinobiose (syrup)
O-ATR	DP3	Arabinotriose (syrup)
O-ATE	DP4	Arabinotetraose (syrup)
O-APE	DP5	Arabinopentaose (syrup)
O-AHE	DP6	Arabinohexaose (powder)

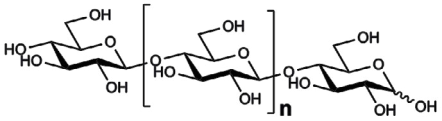


b) Oligosaccharides

Cellooligosaccharides

Substrates for *endo*-cellulase, cellobiohydrolase, β-glucosidase and lipid polysaccharide monooxygenase (LPMO).

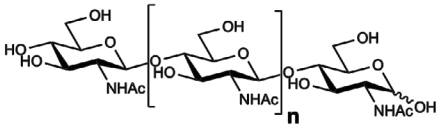
O-CTR	DP3	Cellotriose
O-CTE	DP4	Cellotetraose
O-CPE	DP5	Cellopentaose
O-CHE	DP6	Cellohexaose

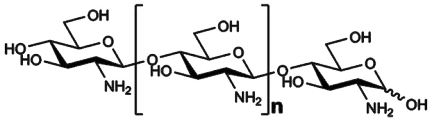


Chito/Chitosanoligosaccharides

Substrates for *endo*-chitosanase, *endo*-1,4-chitinase, hexosaminidase and *N*-acetyl-β-D-glucosaminidase

O-CHI2	DP2	Diacetyl-chitobiose
O-CHIS2	DP2	Chitosanbiose
O-CHI3	DP3	Triacetyl-chitotriose
O-CHIS3	DP3	Chitosantriose
O-CHI4	DP4	Tetraacetyl-chitotetraose
O-CHIS4	DP4	Chitosantetraose
O-CHI5	DP5	Pentaacetyl-chitopentaose
O-CHIS5	DP5	Chitosanpentaose
O-CHI6	DP6	Hexaacetyl-chitohexaose

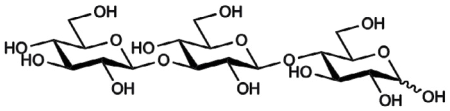




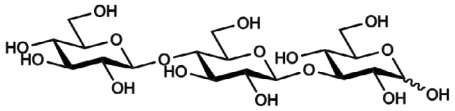
O-CHIS2 DP2 Chitosanbiose

1,3:1,4-β-D-Glucooligosaccharides

Substrates for lichenase/β-glucanase and β-glucosidase.



O-BGTRIA 3^2-β-D-Glucosyl-cellobiose

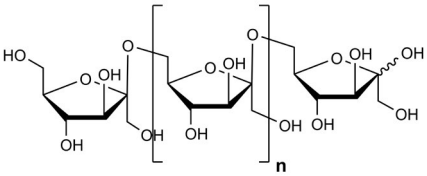


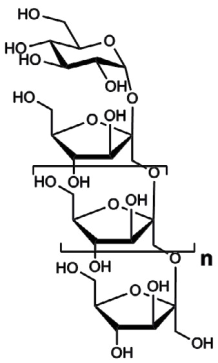
O-BGTRIB 3^1-β-D-Cellobiosyl-glucose

Fructooligosaccharides (FOS)

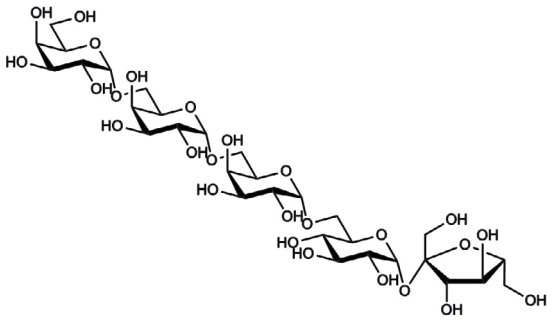
Substrates for *endo*-inulinase, β-fructosidase and *endo*-levanase.

O-KTR	DP3	1-Kestose
O-KTE	DP4	1,1-Kestotetraose
O-KPE	DP5	1,1,1-Kestopentaose
O-INU3	DP3	Inulotriose
O-LEV2	DP2	Levanbiose
O-LEV3	DP3	Levantriose





b) Oligosaccharides



Galactosyl-Sucrose Oligosaccharides

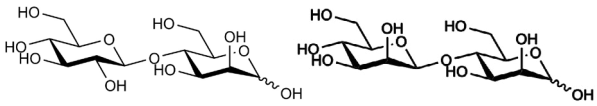
Substrate for α-galactosidase.

O-VER	Verbascose

Glucomannooligosaccharides

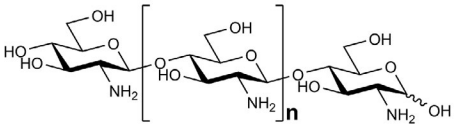
Substrates and standards for glucomannan degrading enzymes.

O-GMM	1,4-β-D-Glucosyl-D-Mannobiose



1,3-α-D-Glucooligosaccharides

Substrates for *endo*-1,3-alpha-glucanase (mutanase), *exo*-1,3-alpha-glucanase

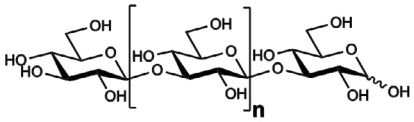


O-NGR	DP2	Nigerose	O-NGR5	DP5	Nigeropentaose
O-NGR3	DP3	Nigerotriose	O-NGR6	DP6	Nigerohexaose
O-NGR4	DP4	Nigerotetraose			

1,3-β-D-Glucooligosaccharides

Substrates for *endo*-1,3-β-glucanase (laminarinase), *exo*-1,3-β-glucanase and β-glucosidase

O-LAM2	DP2	Laminaribiose
O-LAM3	DP3	Laminaritriose
O-LAM4	DP4	Laminaritetraose
O-LAM5	DP5	Laminaripentaose
O-LAM6	DP6	Laminarihexaose

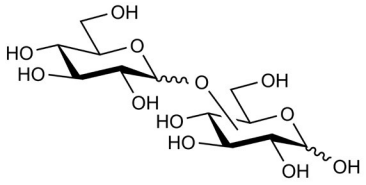


b) Oligosaccharides

Gluco-disaccharides (various linkages)

Substrates for -glucosidase and β-glucosidase.

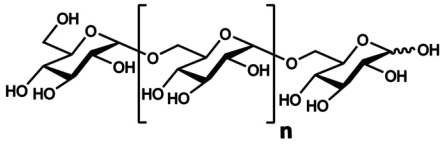
O-LAM2	Glcβ1,3Glc	Laminaribiose
O-NGR	Glcβ1,3Glc	Nigerose
O-IMO2	Glcβ1,6Glc	Isomaltose
O-SOPH	Glcβ1,2Glc	Sophorose



Isomaltooligosaccharides

Substrates for *endo*-1,6-β-dextranase and oligo-β-1,6-glucosidase.

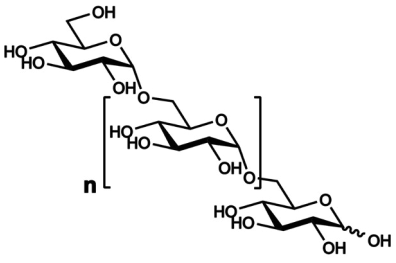
O-IMO2	DP2	Isomaltose
O-IMO3	DP3	Isomaltotriose



Maltooligosaccharides

Substrates for α-amylase and β-amylase.

O-MAL3	DP3	Maltotriose	O-MAL6	DP6	Maltohexaose
O-MAL4	DP4	Maltotetraose	O-MAL7	DP7	Maltoheptaose
O-MAL5	DP5	Maltopentaose	O-MAL8	DP8	Maltooctaose

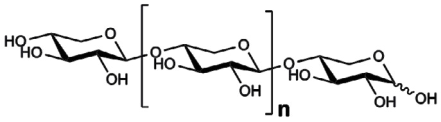


b) Oligosaccharides

1,4-β-D-Xylooligosaccharides

Substrates for *endo*-1,4-β-xylanase and β-xylosidase.

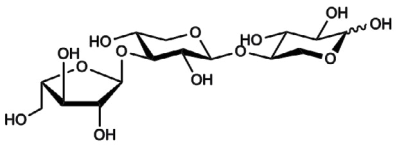
O-XBI	DP2	Xylobiose
O-XTR	DP3	Xylotriose
O-XTE	DP4	Xylotetraose
O-XPE	DP5	Xylopentaose
O-XHE	DP6	Xylohexaose



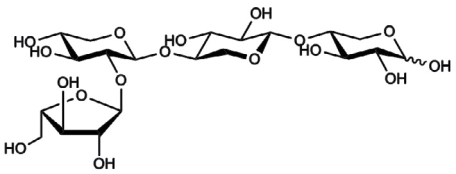
Arabinoxylooligosaccharides

Substrates for α-arabinofuranosidase, β-xylosidase and *endo*-1,4-β-xylanase.

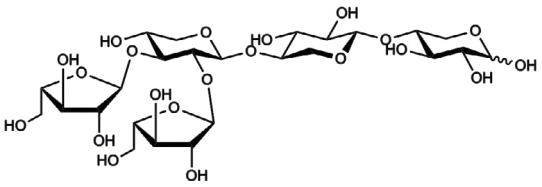
O-A3X 3^2-α-L-Arabinofuranosyl-xylobiose (A^3X)



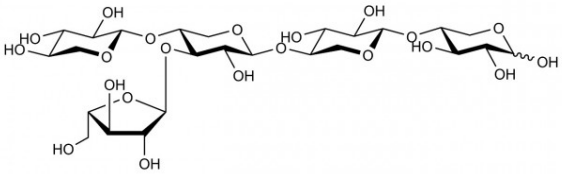
O-A2XX 2^3-α-L-Arabinofuranosyl-xylotriose (A^2XX)



O-A23XX $2^3,3^3$-di-α-L-Arabinofuranosyl-xylotriose ($A^{2,3}XX$)



O-XA3XX 3^3-α-L-Arabinofuranosyl-xylotetraose (XA^3XX)

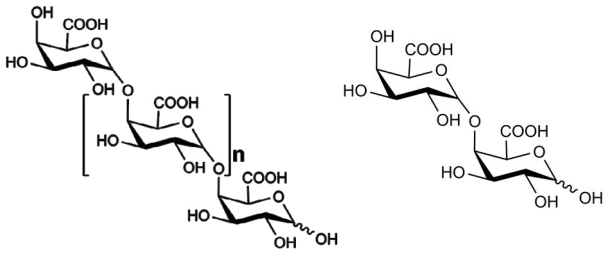


b) Oligosaccharides

Oligogalacturonides

Substrates for β-galacturonanase.

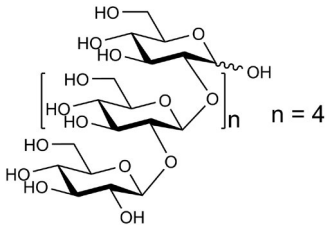
O-GALA2	Digalacturonic acid
O-GALA3	Trigalacturonic acid
O-GALA4	Tetragalacturonic acid



1,2-β-D-Glucooligosaccharides

Substrates for *endo*-1,2-β-glucanase, *exo*-1,2-β-glucanase and β-glucosidase

O-SOPH	Sophorose
O-SOPH3	Sophorotriose
O-SOPH4	Sophorotetraose
O-SOPH5	Sophoropentaose
O-SOPH6	Sophorohexaose



NEOGEN | Megazyme

t + 353 1 286 1220 (worldwide)
e cs@megazyme.com

www.megazyme.com

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