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MOYEN D'UN CATALYSEUR AU CHROME MODIFIE AU FLUOR

(54) Title: PLASTIC HOLLOW BODY MADE OF HIGH DENSITY POLYOLEFINS PRODUCED BY MEANS OF A
FLUORO-MODIFIED CHROME CATALYST

(57) **Abrégé/Abstract:**

The invention relates to a plastic hollow body comprising at least one opening and having a single or multi-layered structure. Said plastic hollow body comprises at least one polyolefin layer which is produced by means of a fluoro-modified chrome catalyst. The invention also relates to the use of the inventive plastic hollow bodies as plastic fuel containers, plastic tanks and plastic bottles or similar.

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(54) **Title:** PLASTIC HOLLOW BODY MADE OF HIGH DENSITY POLYOLEFINS PRODUCED BY MEANS OF A FLUORO-MODIFIED CHROME CATALYST

(54) **Bezeichnung:** KUNSTSTOFFHOHLKÖRPER AUS HOCHDICHTEN POLYOLEFINEN HERGESTELLT MIT EINEM
FLUORMODIFIZIERTEN CHROM-KATALYSATOR

(57) **Abstract:** The invention relates to a plastic hollow body comprising at least one opening and having a single or multi-layered structure. Said plastic hollow body comprises at least one polyolefin layer which is produced by means of a fluoro-modified chrome catalyst. The invention also relates to the use of the inventive plastic hollow bodies as plastic fuel containers, plastic tanks and plastic bottles or similar.

(57) **Zusammenfassung:** Es wird ein Kunststoffhohlkörper mit mindestens einer Öffnung sowie ein- oder mehrschichtigem Aufbau beschrieben, wobei der Kunststoffhohlkörper mindestens eine Schicht aus einem Polyolefin umfasst, das mittels eines fluormodifizierten Chrom-Katalysators hergestellt wurde. Ferner wird die Verwendung erfindungsgemässer Kunststoffhohlkörper als Kunststoffkraftstoffbehälter, Benzinkanister, Kunststofftank und Kunststoffflasche oder dergleichen beschrieben.



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PLASTIC HOLLOW BODY MADE OF HIGH DENSITY POLYOLEFINS PRODUCED BY
MEANS OF A FLUORO-MODIFIED CHROME CATALYST

5 The present invention relates to hollow plastic articles produced using specific polyolefin materials and having a structure of one or more layers and having improved component strength.

The present invention further relates to the use of hollow
10 plastic articles of this type with improved component strength as fuel tanks in automotive construction.

Hollow plastic articles used for storing or transport of hazardous liquid materials have been known for a long time.
15 Particularly in vehicle construction, hollow plastic articles used as fuel tanks have almost completely displaced the previous conventional tanks made from metallic materials. Plastics are moreover now almost the only material used to produce portable containers of all types, such as fuel canisters and plastic
20 bottles for combustible liquids, hazardous substances, and the like. The particular advantage of plastic containers and tanks is especially their low weight/volume ratio, the avoidance of corrosion problems, and also, in particular for vehicle construction, better crash properties.

25 Hollow plastic articles are in many cases blowmolded from polyolefins, mostly from high-density polyethylene (HDPE). The disadvantage of polyethylene vessels of this type is primarily their low level of barrier action with regard to the permeation
30 of their contents. For automobiles there are strict legal requirements for the avoidance of ozone-forming emissions, e.g. fuels. The low level of barrier action of polyolefins with respect to the permeation of volatile substances therefore means that additional measures generally have to be taken to reduce
35 permeation, the most important of these being the fluorination of the container surface or the introduction of a barrier layer made from polar barrier plastic. Barrier layers of this type are mostly introduced into the container wall in the prior art by what is known as multilayer coextrusion blowmolding.

40 Barrier layers in turn mostly bring about lower mechanical strength in coextrusion-blowmolded containers. Containers comprising a barrier layer are in particular more susceptible than uncoated high-density polyethylene containers to impact at
45 low temperatures.

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There are particular problems which arise especially in the construction of plastic fuel tanks from polyethylene. Plastic fuel tanks are classed as components with safety implications in automotive construction and are therefore subject to particularly high requirements in relation to component strength, crash properties and fire resistance. In the construction of plastic fuel tanks there is therefore a particular need to comply with the specific requirements placed upon components in this class.

European patent EP 0 645 400 describes plastic fuel tanks using polyethylenes of a new type with particular properties. A substantive feature of these materials is an elongational viscosity ratio characterized by the dimensionless value R described in that specification. According to EP 0 645 400, suitable polyethylene materials achieve R values of at least 2.5. The disadvantage of these materials is that the products have to have high molar masses to achieve the required high R values. This in particular impairs processing performance, either by restricting the output or by producing high melt pressures. In addition, the materials according to EP 0 645 400 tend to develop flow anomalies which can cause thin areas in the finished part.

There is therefore a considerable need for new polyolefin materials, in particular polyethylene, which can produce hollow plastic articles with increased component strength, while their processing properties remain as good as those of the materials conventionally used nowadays for these applications.

It is known that the properties of polyolefins can be controlled and modified over a wide range via the nature and structure of the polymerization catalyst used and of the support material used. The makeup of the catalyst support and of the catalytically active material thereupon, the structure of the same, and the activation conditions have a decisive effect on the performance of the catalyst in the polymerization process, on the activity of the catalyst, and on the structure and properties of the resultant polymer. Very small changes in the makeup or structure, either of the catalytically active material or of the support material, therefore frequently lead to surprising effects.

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For example, US 3,130,188 discloses that silica-gel-supported chromium oxide catalysts modified with inorganic fluorides, such as ammonium hexafluorosilicate, have increased polymerization activity, and that the resultant polyethylene has a narrow molecular weight distribution.

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It is an object of the present invention to produce hollow plastic articles using a new type of polyolefin materials which give increased component strength and avoid the abovementioned disadvantages of the prior art. A further object of the present invention is to provide hollow plastic articles with improved properties, using a new type of polyolefin materials which can be prepared without any significant change in the material processing properties from those of conventional standard materials. In particular, it is an object of the present invention to provide hollow plastic articles with increased component strength, using new polyethylene materials.

We have found that this object is achieved by means of a hollow plastic article which has at least one opening wherein the hollow plastic article, whose structure has one or more layers, has at least one layer made from a polyolefin which was prepared using a fluorine-modified chromium catalyst.

Advantageous embodiments are given by combination with the features of the dependent subclaims.

Surprisingly, it has now been found that by using fluorine-modified chromium catalysts of Phillips type it is possible to prepare polyolefins whose property profile is ideally suitable for use in hollow plastic articles. It has been found that using fluorine-modified chromium catalysts it is possible to prepare polyolefin materials which have a balanced ratio of environmental stress cracking resistance to toughness. The polymers obtained have high environmental stress cracking resistance together with high impact strength. This is particularly surprising since the relationship between these properties is usually precisely the opposite, i.e. impact strength falls when environmental stress cracking resistance increases, and vice versa. These unusual properties of polyolefins prepared by way of fluorine-modified chromium catalysts can be used particularly advantageously in producing hollow plastic articles of the invention.

Surprisingly, hollow plastic articles, in particular plastic fuel tanks, which use polyolefin materials prepared with the aid of fluorine-modified chromium catalysts have excellent component strength, due to the high environmental stress cracking resistance and the high impact strength, while at the same time the conditions for processing the material are favorable.

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The use of polyolefins of the invention is particularly effective in giving mechanical properties superior to the prior art when they are used in multilayer hollow plastic articles which comprise a permeation-reducing barrier layer.

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The polyolefin materials used according to the invention are homo- or copolymers of ethylene and/or of propylene, the comonomers used being 1-alkenes, such as propene, butene, hexene, octene, or the like. Particular preference is given to high-density homopolymers of ethylene (HDPE), and also to high-density ethylene copolymers using butene and/or hexene as comonomers.

The polyolefin materials to be used in hollow plastic articles of the invention are prepared using a fluorine-modified chromium catalyst. To this end, known prior-art catalysts are fluorine-modified by way of suitable fluorinating agents. Conventional chromium-containing polymerization catalysts which comprise silica gel or modified silica gel as support material and chromium as catalytically active component have long been known in the prior art as Phillips catalysts in the preparation of high-density polyethylene. Phillips catalysts are generally activated at high temperatures before the polymerization in order to stabilize chromium in the form of a chromium(VI) species on the catalyst surface. This species is reduced by adding ethylene or reducing agents in order to develop the catalytically active chromium species.

Polyolefin materials, in particular polyethylene materials, which can be used for producing hollow plastic articles of the invention are produced by way of fluorine-modified heterogeneous chromium catalysts.

Particularly suitable catalysts are air-activated silica gel-supported chromium catalysts which are modified using suitable inorganic fluorinating agents. Spherical support materials based on silica hydrogels with a relatively high solids content of from 10 to 25% (calculated as SiO_2) are particularly suitable. These support materials are then loaded with suitable chromium compounds and activated in a stream of anhydrous oxygen at a concentration of 10% by volume, at from 400 to 1100°C.

The preparation of suitable catalysts is described in DE 25 40 279, by way of example, and is incorporated herein by way of reference, and the fluoride doping which is also needed here may, if desired, take place during the preparation of catalyst precursors (i.e. during the impregnation step) or in the

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activator during the activation step, for example by coimpregnation of the support with a solution of the fluorinating agent and the desired chromium compound, or by adding fluorinating agents within the gas stream during air-activation.

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Suitable fluorinating agents for doping supported chromium catalysts are any of the usual fluorinating agents, such as ClF_3 , BrF_3 , BrF_5 , ammonium hexafluorosilicate (NH_4SiF_6), ammonium tetrafluoroborate (NH_4BF_4), ammonium hexafluoroaluminate (NH_4AlF_6), NH_4HF_2 , ammonium hexafluoroplatinate (NH_4PtF_6), ammonium hexafluorotitanate (NH_4TiF_6), ammonium hexafluorozirconate (NH_4ZrF_6), and the like. Particular preference is given to supported chromium catalysts doped with ammonium hexafluorosilicate.

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The usual polymerization processes of the prior art are used, with fluorine-modified chromium catalysts, to prepare polyolefins which can be used according to the invention, examples of these processes being suspension polymerization or else dry-phase polymerization, gas-phase polymerization with agitation, gas phase polymerization in a fluidized bed, and solution polymerization. These processes may be carried out either in single-reactor systems or else in reactor-cascade systems.

Polyolefins prepared using fluorine-modified chromium catalysts have a balanced property profile. When fluorine-doped chromium catalysts are used to prepare copolymers of propylene or of ethylene with α -olefins the polymers obtained give excellent processing and have a low flow rate. Polyethylene prepared in this way has a narrower molecular weight distribution than polyethylene prepared with undoped catalysts, but this distribution very surprisingly does not affect the processing properties of the material.

The density of polyethylene homo- or copolymers which can be used according to the invention and which have been prepared using fluorine-doped chromium catalysts is in the range from 0.930 to 0.960 g/cm³, preferably from 0.945 to 0.955 g/cm³, in particular from 0.947 to 0.953 g/cm³.

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The flow properties of materials which can be used according to the invention are characterized by a melt flow rate MFR (190°C/21.6 kg) of from 2 to 8 g per 10 minutes. Preference is given to materials with melt flow rates of from 3 to 7 g per 10 minutes, in particular from 4 to 6 g per 10 minutes.

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Using these materials it is possible to produce hollow plastic articles whose structure has one or more layers and which have markedly increased component strength. This stems in particular from the high environmental stress cracking resistance of the
5 fluorine-catalyzed polyolefins used according to the invention, and also from their high impact strength.

The structure of hollow plastic articles of the invention may have one or more layers, at least one layer being composed of a
10 polyolefin material which was prepared by way of a fluorine-modified chromium catalyst.

According to the invention, preference is given to a multilayer structure where at least one barrier layer is present to reduce
15 permeation of volatile substances and is composed of a polar barrier polymer. The multilayer structure, for example of a plastic fuel tank wall, has the particular advantage that the permeation-reducing barrier layer, the material properties of which lead to poorer processing conditions and/or poorer
20 mechanical properties in the finished component, can be embedded between two polyolefin layers which have been prepared by way of fluorine-modified catalysts. Consequently, in particular during coextrusion blowmolding, the processing properties of a material of this type having more than one layer are primarily affected by
25 the favorable properties of the polyolefin. In addition, the properties of the polyolefin material are decisive in determining the mechanical properties of the desired component, and it is therefore possible to obtain hollow plastic articles of the invention with markedly increased component strength.

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However, it is also possible to use processes such as fluorination, surface coating or plasma polymerization to coat the surface of the HDPE with the base layer.

35 Particularly preferred embodiments of hollow plastic articles of the invention provide a six-layer structure which comprises the following layers, from the inside to the outside: polyolefin (of the invention), adhesion promoter, barrier layer, adhesion promoter, regrind, polyolefin (of the invention).

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It is particularly preferable to use high-density polyethylenes (HDPEs) prepared by way of fluorine-modified chromium catalysts.

The thicknesses of the layers, in the same sequence and in each
45 case based on the total thickness of the container wall, are: polyolefin (or HDPE) 10-40%, adhesion promoter 1-5%, barrier

polymer 1-10%, adhesion promoter 1-5%, regrind layer 10-82%, polyolefin (or HDPE) 5-30%.

Examples of barrier polymers which may be used according to the invention are ethylene-vinyl alcohol copolymers, polyvinyl alcohol, polyester, polyamide, fluoropolymers (e.g. PTFE, PVDF), and the like. Particularly preferred barrier polymers are ethylene-vinyl alcohol copolymers, e.g. the commercially available grades EVAL® (Kuraray) and Soarnol® (Elf Atochem), and also polyamides, e.g. Ultramid® (BASF).

Adhesion promoters which may be used according to the invention are those materials which are suitable for ensuring that the barrier polymer is compatible with, or forms a bond to, the polyolefin. Preferred adhesion promoters are based on block copolymers of maleic anhydride with HDPE, LDPE, or LLDPE, for example the polymer marketed by Mitsui as Admer® GTSE.

The material of the regrind is composed of mixtures of suitable plastics which are generally produced as waste in plastics processing. The predominant proportion of the regrind is preferably HDPE together with typical barrier polymers. The regrind layer is preferably produced from what is known as flash, as polymer residues during the production of the hollow plastic articles.

The hollow plastic articles according to the invention are preferably produced by coextrusion blowmolding.

Hollow plastic articles of the invention may be used for a wide variety of applications and products. These are in particular plastic fuel tanks in automotive construction, canisters, and tanks of all types for the storage or transport of gasoline, heating oil, diesel, and the like, solvent (receiver) tanks, plastic bottles for liquids or fluid solids, transport containers on utility vehicles, for example for crop sprays for agricultural use, solvent containers, etc.

The invention will be illustrated in further detail using the examples below, which are not to be regarded as limiting. The examples in particular show that materials prepared using fluorine-modified chromium catalysts can be used to produce hollow plastic articles with particularly good mechanical properties. The data required to describe the products were determined as stated to ISO standards.

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Processing performance is described on a blowmolding machine firstly via the melt pressure in the extruder for the PE interior layer and secondly via the base gap width of the die. The base gap is that needed to achieve the required tube thickness: the smaller the base gap, the greater the swelling of the material under the conditions of processing.

Plastic fuel tanks of the invention were produced for use as a tank in automotive construction. The tanks were tested for impact resistance using a drop test. To this end, a glycol-water mixture was placed in 8 tanks of each tank type followed by cooling to 40°C. The tanks are dropped 6 m from 4 different positions. The test was carried out twice, with 2 tanks, for each drop position. For evaluation, the number of drops which did not result in fracture is calculated as a ratio of the maximum number of drops (in this case 8) and given as a percentage.

The environmental stress cracking resistance of the tanks was tested by placing a wetting agent (in this case 5% of Nekanil W in water) in the tanks, followed by storage at a pressure of 0.3 bar for 80 hours at 50°C. The test is passed if no leaks arise during this period.

The fire test was carried out to ECE R34 in the actual bodywork of a car. In addition to the ECE test itself, which requires direct flame application for 60 seconds followed by indirect flame application for 60 seconds, further experiments increased the period of direct flame application in steps of 6 seconds. The values given below have been obtained by dividing the fire-test times over which the tank remained leak-free by the wall thickness measured prior to the fire test in the region affected.

35 Example 1

An ethylene-hexene copolymer was prepared using a fluorine-modified silica gel-supported chromium catalyst prepared by a method based on DE 25 40 279, the fluorine modification being carried out by coimpregnating the support material with chromium compound and ammonium hexafluorosilicate, followed by air-activation of the catalyst at 610°C in a fluidized-bed activator. The polymerization takes place in a 30 m³ Phillips loop reactor. Melt flow rate and density were adjusted via the reactor temperature and the concentration of hexene and ethylene in the

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suspension medium (isobutane). The reactor pressure was 39 bar. The polymerization data can be found in Table 1.

The polyethylene copolymer prepared in this way was processed on
5 a Krupp Kautex KBS 2 coextrusion blowmolding plant to give plastic fuel tanks with a six-layer structure. The following sequence of layers was selected, from the inside to the outside (layers in percentage based on the total thickness of the tank wall):

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Polyethylene (of the invention) 33%

Adhesion promoter (Mitsui Admer[®] GT5E): 2%

15 Barrier layer (Kuraray EVAL[®] F 101): 3%

Adhesion promoter (Mitsui Admer[®] GT5E): 2%

Regrind: 45%

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Polyethylene (of the invention) 15%

The empty weight of the tanks is 6.5 kg.

25 Example 2 (comparative example)

Plastic fuel tanks were produced under conditions based on those of Example 1. The catalyst used comprised a catalyst prepared as in DE 25 40 279, without fluorine modification. The catalyst was
30 activated at 600°C by air in a fluidized-bed activator. The polymerization was carried out as in Example 1. The polymerization data can be found in Table 1.

The product prepared in this way was processed as described above
35 to give coextrusion-blowmolded tanks with an empty weight of 6.5 kg.

Example 3 (comparative example)

40 In this example commercially available polyethylene (Lupolen[®] 4261 AG from BASF) was used to produce the coextrusion-blowmolded plastic fuel tanks. The production and layer structure of the tanks was as given in Example 1.

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Table 1: Polymerization data and polymer properties

5		Unit	Example 1	Example 2 (comparative example)	Example 3 (comparative example)
	Reactor temp.	°C	103.5	104.5	103.2
	Ethene concentration	% by volume	12.5	9.0	10.0
10	Hexene concentration	% by volume	0.12	0.15	0.30
	Productivity	kg PE/kg cat.	5500	4000	4800
	Output	kg/h	6000	5500	5000
	Bulk density	g/l	500	495	495
15	MFR (190/21.6 kg)	g/10 min (ISO 1133)	4.7	6	6
	Density	g/cm ³ (ISO 1183)	0.951	0.951	0.945

20 The processing properties, and also the properties of the finished components, are compared in Table 2.

Table 2: Processing properties and component properties

25		Unit	Example 1	Example 2 (comparative example)	Example 3 (comparative example)
30	Melt pressure (PE interior layer)	bar	138	132	136
35	Melt temperature (PE interior layer)	°C	221	222	218
	Base gap	%	18	19	19
	Drop test (-40°C)	%	88	75	75
	ESCR		+	+	+
40	Fire test (ECE R 34)	sec/min	42.9	37.5	41.3
	R value*		2.43	2.39	2.4

+ = passed

45 * R value measured as given in EP 645 400 B1

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It is noticeable that in Table 2 the impact resistance given by the drop test for plastic fuel tanks of the invention is markedly higher than for the comparative examples. It is also noticeable that although the R value of the plastic fuel tank of the
5 invention is below the value of 2.5 mentioned as a minimum by EP 645 400 it is possible to obtain components with a markedly improved property profile.

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We claim:

1. A hollow plastic article with at least one opening,
5 wherein the hollow plastic article, whose structure has one or more layers, has at least one layer made from a polyolefin having a density of from 0.943 to 0.955 g/cm² [sic] and a melt flow rate MFR (190°C/21.6 kg) of from 2 to 8 g/10
10 minutes, prepared using a fluorine-modified chromium catalyst.
2. A hollow plastic article as claimed in claim 1,
15 wherein the polyolefin comprises a homopolymer or copolymer of ethylene.
3. A hollow plastic article as claimed in any of the preceding claims,
20 wherein the polyolefin comprises a copolymer of ethylene, in which an α -olefin having from 3 to 8 carbon atoms is used as comonomer.
4. A hollow plastic article as claimed in claim 3,
25 wherein the comonomer comprises 1-butene or 1-hexene.
5. A hollow plastic article as claimed in any of the preceding claims,
30 wherein the density of the polyolefin used is from 0.945 to 0.953 g/cm² [sic].
6. A hollow plastic article as claimed in any of the preceding claims,
35 wherein the polyolefin has a melt flow rate MFR (190°C/21.6 kg) of from 3 to 7 g/10 minutes.
- 40 7. A hollow plastic article as claimed in any of the preceding claims,
which has a permeation-reducing coating.
- 45 8. A hollow plastic article as claimed in any of the preceding claims,

AMENDED SHEET

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wherein the structure of the hollow plastic article has more than one layer and comprises, from the inside to the outside, a polyolefin layer, an adhesion promoter layer, a barrier polymer layer, an adhesion promoter layer, a regrind layer, and a polyolefin layer.

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9. The use of a hollow plastic article as claimed in any of the preceding claims as a plastic fuel tank in a motor vehicle.
- 10 10. The use of a hollow plastic article as claimed in any of the preceding claims as a fuel canister, fuel tank for storage and transport of fuels, diesel, heating oil or the like, a transport container on utility vehicles, such as those for agricultural sprays, solvent containers, plastic bottles, or the like.
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