US 5364950, and also US 5763677 and "*Catalyst Separation, Recovery and Recycling*", edited by D. J. Cole-Hamilton, R. P. Tooze, 2006, NL, pages 25-26, describe the formation of what are called "*poisoning phosphites*" as secondary reactions or ligand degradation reactions. These "*poisoning phosphites*" form in the course of use of aryl phosphite-modified rhodium complexes during the hydroformylation reaction. In the course of ligand degradation here, an aryl group is exchanged for an alkyl group in the hydroformylation product.

As well as the formation of the unwanted "*poisoning phosphites*", the phosphite ligand can also be degraded in the course of a hydrolysis reaction by the water traces formed in aldehyde condensation.

A consequence of these degradation reactions of the ligands is that the concentration of hydroformylation-active rhodium complex species decreases over the course of time and is accompanied by a loss of reactivity.

It is common knowledge that, in a continuous mode of hydroformylation, ligand(s) and optionally further components have to be replenished during the course of the reaction, i.e. have to be added additionally after commencement of the reaction (see DE 10 2008 002 187 A1).

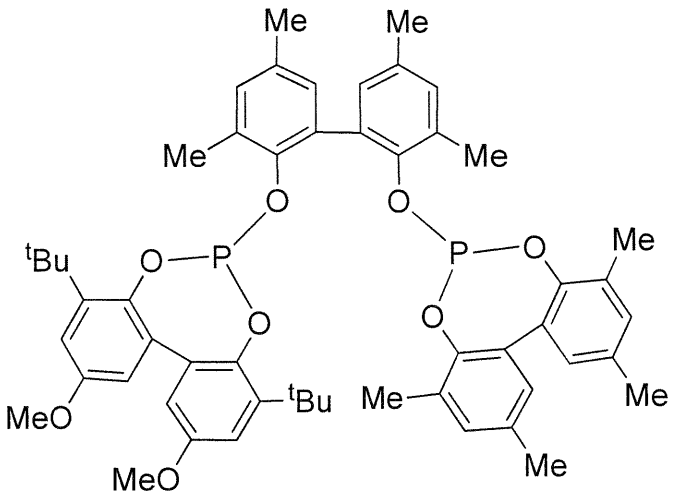
The technical object of the invention is the provision of a novel ligand which does not have the above-detailed disadvantages from the prior art in the hydroformylation of unsaturated compounds, but instead has the following properties:

1) a high activity,
2) a high n-regioselectivity in relation to the hydroformylation,
3) a high service life and long-term stability.

A high service life means that the hydroformylation-active composition comprising the ligand in addition to further components has a low tendency to degradation of this ligand and/or to decomposition of this ligand in hydroformylation-inhibiting components, for example the "*poisoning phosphites*".

Summary

In an aspect, there is provided a compound of the formula (1):



(1)

In another aspect, there is provided a process for preparing a compound of formula (1), comprising the process steps of:

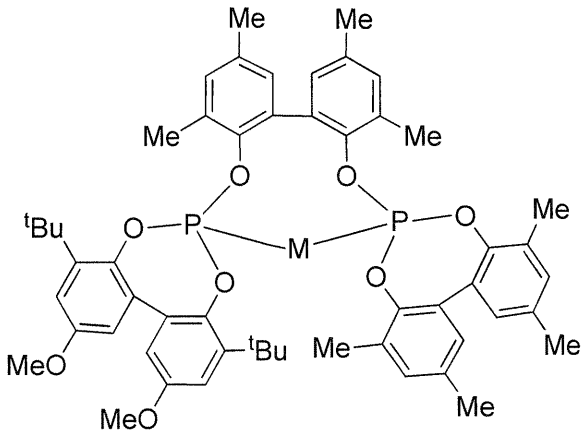
i) oxidatively coupling 2,4-dimethylphenol to give 3,3′,5,5′-tetramethyl-2,2′-dihydroxybiphenyl;

ii) oxidatively coupling 3-tert-butyl-4-hydroxyanisole to give 5,5′-dimethoxy-3,3′-di-tert-butyl-2,2′-dihydroxybiphenyl;

iii) reacting 3,3′,5,5′-tetramethyl-2,2′-dihydroxybiphenyl from i) with PCl_3 to give the phosphorochloridite derivative under inert gas atmosphere;

iv) reacting at least 2 equivalents of the phosphorochloridite derivative from iii) with 1 equivalent of the 5,5′-dimethoxy-3,3′-di-tert-butyl-2,2′-dihydroxybiphenyl from ii) under inert gas atmosphere.

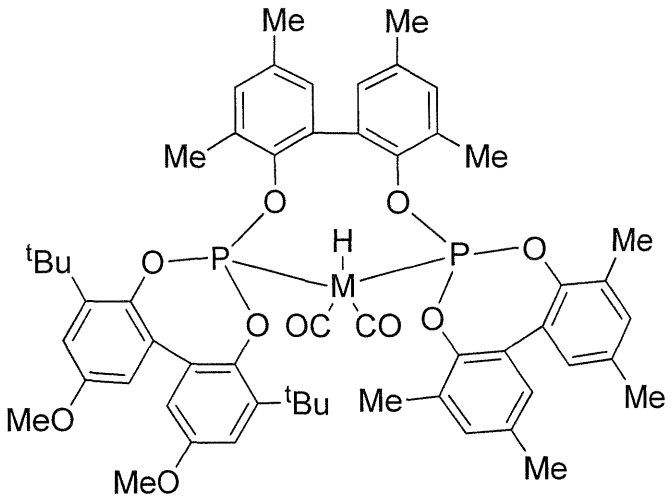
In another aspect, there is provided a compound of the formula (2):



(2)

where M is selected from Fe, Ru, Os, Co, Rh, Ir, Ni, Pd, Pt, and M may enter into additional bonds.

In another aspect, there is provided a compound of the formula (3):



(3)

where M is selected from: Fe, Ru, Os, Co, Rh, Ir, Ni, Pd, Pt.

In another aspect, there is provided a mixture comprising a compound of the formula (2) and/or (3), where the mixture additionally comprises a compound of the formula (1) not bonded to M.

In another aspect, there is provided a process for hydroformylating an unsaturated compound or a mixture of unsaturated compounds, comprising the process steps of:

a) initially charging a compound according to formula (1) or a composition described herein,

b) introducing a gas mixture comprising carbon monoxide and hydrogen

c) adding at least one unsaturated compound or a mixture of unsaturated compounds.

The object is achieved by a compound of formula (1):