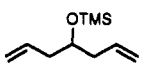
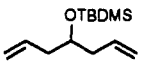
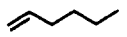
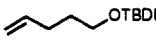
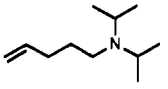
Table I[a]

entry	monomer	metallocene (mmol)	$B(C_6F_5)_3$ (mmol)	temp °C[b]	time (min)	conversn (GC)	turnovers[c]	M_w/M_n[d]	M_n[e]
		$Cp^*_2ZrMe_2$							
1		(0.010)	(0.0050)	22	30	59	280	4.3	920
2		(0.020)	(0.010)	-25	120	98	249	2.7	8100
		(EBTHI)$ZrMe_2$							
3		(0.042)	(0.021)	24	11	81	97	5.3	2900
		$Cp^*_2ZrMe_2$							
4		(0.010)	(0.0049)	22	10	63	324	3.3	670
5		(0.010)	(0.0049)	-25	120	45	209	2.1	11000
		(EBTHI)$ZrMe_2$							
6		(0.010)	(0.0049)	22	10	72	351	3.4	500
7		(0.010)	(0.0049)	-25	120	20	95	1.8	6300
		$Cp^*_2ZrMe_2$							
8		(0.020)	(0.011)	22	30	40	97	2.7	1800
9		(0.020)	(0.011)	-25	120	77	187	2.9	10000
		$Cp^*_2ZrMe_2$							
10		(0.041)	(0.020)	22	60	75	91		2900
11		(0.039)	(0.023)	-25	120	68	78		8800
		(EBTHI)$ZrMe_2$							
12		(0.057)	(0.028)	22	60	72	62		5400

[a] Conditions: A toluene solution of $B(C_6F_5)_3$ was added to a toluene solution of metallocene and 5.0 mmol of monomer; total solution volume = 5 mL. Reactions were monitored by GC. [b] Temperature = ±3 °C. [c] Turnovers = millimoles of monomer consumed per millimole of metallocene. [d] Determined by GPC analysis. GPC analyses of the polyamines were irreproducible. [e] Estimated from ^1H NMR end-group analysis. Cp* = pentamethylcyclopentadienyl, EBTHI = ethylene-1,2-bis(η^5-4,5,6,7-tetrahydro-1-indenyl), TMS = trimethylsilyl, TBDMS = *tert*-butyldimethylsilyl.

derivatives. $[(EBTHI)ZrMe]^+X^-$ catalysts are inactive for the polymerization of 4-TMSO-1,6-heptadiene but readily polymerize the more sterically hindered TBDMS-protected monomer (average activity at 81% conversion = 530 turnovers/h, 88% cyclized by ^1H NMR).

Activities for the polymerization of 5-TBDMSO-1-pentene and 5-(*N*,*N*-diisopropylamino)-1-pentene in the presence of $[Cp^*_2ZrMe]^+X^-$ are lower than that for 1-hexene. Average activities range from 2700 turnovers/h for 1-hexene (44% conversion) to 190 turnovers/h for 5-TBDMSO-1-pentene (40% conversion) to 130 turnovers/h for 5-(*N*,*N*-diisopropylamino)-1-pentene (55% conversion). At least 100 turnovers can be achieved for both functionalized monomers.[27,28] Chiral *rac*-$[(EBTHI)ZrMe]^+X^-$ catalysts are active for the homopolymerization of 1-hexene and 5-(*N*,*N*-diisopropylamino)-1-pentene but not for 5-TBDMSO-1-pentene. Preliminary ^{13}C NMR analyses of polymers obtained in the presence of $[(EBTHI)ZrMe]^+X^-$ are consistent with highly isotactic microstructures.[29]

Treatment of poly(methylene-3,5-(1-TMSO)cyclohexanediyl) with aqueous HCl in hexanes affords the corresponding *polyalcohol* as a white powder (eq 1, 98% yield) which was soluble in DMF, DMSO, and pyridine.[30] Thermogravimetric analysis of this material shows <5% decomposition below 330 °C.[31] Treatment of poly(5-(*N*,*N*-diisopropylamino)-1-pentene) with HCl yields the corresponding poly(ammonium chloride) which is *water soluble* (eq 2).[32]

A major advantage of these metallocene-based catalysts is that the ligand system can be systematically modified to provide the optimal combination of catalytic activity, stereospecificity, and tolerance to functionality. Further studies are underway to extend these results to the synthesis of *optically active, functionalized polyolefins* via enantioselective cyclopolymerization.[23c]

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Supplementary Material Available: Experimental procedures and polymer characterization (8 pages). Ordering information is given on any current masthead page.

(27) In contrast, <50 turnovers were observed for the homopolymerization of functional monomers with $TiCl_3/AlR_3$ catalysts (see refs 7, 9, 11b).

(28) Attempts to directly compare rates for each monomer were frustrated by the sensitivity of the catalyst to impurities. For reproducible results, 5-TBDMSO-1-pentene required approximately 2 times the catalyst concentration and 5-(*N*,*N*-diisopropylamino)-1-pentene required approximately 4 times the catalyst concentration to obtain rates comparable to 1-hexene.

(29) Poly(5-(*N*,*N*-diisopropylamino)-1-pentene): >90% mm dyads. Poly(1-hexene): >90% mm dyads. See: Asakura, T.; Demura, M.; Nishiyama, Y. *Macromolecules* **1991**, *24*, 2334.

(30) Characterized by IR, ^1H and ^{13}C NMR (DMSO-d_6), and elemental analysis.

(31) In contrast, poly(vinyl alcohol) decomposes below 250 °C (see ref 5).

(32) *Polymeric Amines and Ammonium Salts*; Goethals, E. J., Ed.; Pergamon Press; New York, 1980. Characterized by IR, ^1H and ^{13}C NMR ($CDCl_3$), and elemental analysis.

Mechanism of Peptide Release from Major Histocompatibility Complex Class II Molecules

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Major histocompatibility complex (MHC) class II heterodimeric ($\alpha\beta$) proteins are present as complexes with peptides on the outer plasma membranes of antigen presenting cells.[1] A single MHC class II molecule can bind many different peptides. A significant aspect of the reactions between peptides and solubilized MHC class II molecules is that complexes dissociate slowly ($t_{1/2}$

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(1) Rothbard, J. B.; Gefter, M. L. *Annu. Rev. Immunol.* **1991**, *5*, 477-540.

0002-7863/92/1514-9680$03.00/0

Table I. Dissociation Half-Times of Peptides from I-A^d at pH = 5.3 and 40 °C

peptide[a]	$t_{1/2}$ (h)	k (s^{-1}) × 10^6
F-ISQAVHAAHAEINEAGKY-NH_2	107	1.8
F-AERADLIAYLKQATAK	92	2.1
Ac-QAVHAAHAEINEAGKY-F	99	1.9
F-GAAHA-NH_2	96	2.0

[a] Ova peptides were prepared as described.[10] The FpCyt*c* peptide was prepared and labeled with fluorescein isothiocyanate at the N-terminus. The FpCyt*c* peptide stimulates the T-cell hybridoma 2B4, which is specific for complexes between I-E^k–pCyt*c*(88–104)[5]. Ac- denotes N-terminal acetylation, and -NH_2 denotes C-terminal amidation. There is a 5–10% uncertainty in the half-times and rate constants.

= 5–300 h) and also form slowly.[2,3] Recent work[4–6] has shown that a first-order reaction precedes the binding of peptide. In our experiments this first-order reaction was thought to involve the dissociation of endogenous peptides, which are known to occupy the binding sites of MHC class II molecules.[7] In this communication we report that the half-times for the dissociation of a number of labeled peptides (P*) from preformed complexes ($\alpha\beta$P*) are nearly *constant*, independent of peptide sequence, or length. This is a totally unexpected result, particularly in view of the fact that bound peptide stabilizes the $\alpha\beta$ heterodimer against dissociation into separate α and β subunits.[6,8] The kinetic results reported here indicate that a peptide-independent conformational change precedes the release of bound peptide.

The mouse MHC class II protein I-A^d is known to bind a 17-residue fragment of chicken ovalbumin (representing residues 323–339 of ovalbumin, Ova323–339)[9] as well as truncated Ova peptides (5- and 6-mers).[10] I-A^d also forms complexes with a peptide from pigeon cytochrome *c* (residues 89–104 of pigeon cytochrome *c*, pCyt*c*89–104).[9] I-A^d–peptide complexes were prepared by incubating purified I-A^d with a large excess of the desired fluoresceinated peptide at pH = 5.3 for up to 48 h at 37 °C.[11,12] Complexes were separated from free peptide by passage down a TSK G3000 SW gel filtration column (Pharmacia) with fluorescence detection as described.[6]

The rate of peptide release from preformed complexes was measured for four different I-A^d–peptide complexes (Figure 1).[13,14] The results are summarized as follows: (i) Two 16-mers that have completely different sequences nevertheless dissociate from I-A^d with nearly identical half-times ($t_{1/2}$(FpCyt*c*) = 92 h; $t_{1/2}$(Ova325–240-F) = 101 h) (Table I). (ii) The site of attachment of the fluorophore F does not significantly affect the dissociation kinetics ($t_{1/2}$(FOva323–340) = 92 h; $t_{1/2}$(Ova325–340-F) = 101 h). (iii) FOva(328–332), a 5-mer, yields the same half-time for dissociation ($t_{1/2}$(FOva328–332) = 96 h) as the long peptides (Table I).

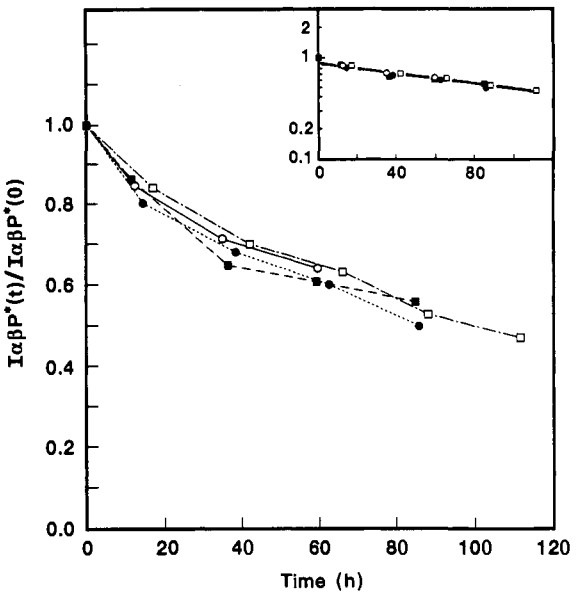

Figure 1. The dissociation of labeled peptide from preformed I-A^d–peptide complexes at pH = 5.3 (40 °C). Four different complexes were prepared: ■, I-A^d–Ova(325–340)F; ●, I-A^d–FpCyt*c*(89–104); □, I-A^d–FOva(323–340); ○, I-A^d–FOva(328–332). The pH of the I-A^d–peptide solution was adjusted from pH 7 to 5.3 by the addition of an aliquot of a concentrated citrate buffer.[6] For each sample, unlabeled peptide was added to a final concentration of 100 μM. Aliquots were periodically removed and injected on the HPSEC at the indicated times to determine the amount of complex ($\alpha\beta$P*). The data are normalized by dividing the intensity of the $\alpha\beta$P*(t) signal by the initial intensity, $I\alpha\beta P^*(t)/I\alpha\beta P^*(0)$. Initial time points are after 2 h of incubation. The lines through the points are to help guide the eye. Inset: semilog plot of the data.

The kinetic results are consistent with a rate-limiting slow transition from a "closed", unreactive heterodimeric state to an "open", reactive heterodimeric state (eq 1), from which bound peptide dissociates (eq 2).[15] That is, at 40 °C and pH 5.3 the peptide dissociation is simple first-order if $k_{off} \gg k_{co}$. The

$$\{\alpha\beta P^*\}_c \xrightarrow{k_{co}} \{\alpha\beta P^*\}_o \quad \text{slow} \tag{1}$$

$$\{\alpha\beta P^*\}_o \xrightarrow{k_{off}} \{\alpha\beta\}_o + P^* \tag{2}$$

unexpected equality of the dissociation rate constants is then plausible if slow reaction 1 does not depend in a sensitive way on peptide structure, even though reaction 2 must. The heterodimer splitting reaction studied previously[5,6] is subsequent to reaction 2.

$$\{\alpha\beta\}_o \rightarrow \alpha + \beta \tag{3}$$

It is reaction 3 under our experimental conditions that makes it difficult to measure the reverse reaction 2.

In the present work we also report evidence for a kinetic intermediate when the reaction is carried out at lower temperatures, 20 and 30 °C. For example, at 20 °C the loss of the $\alpha\beta$P* signal does not follow first-order kinetics over the first 24 h of incubation:

(2) Sadegh-Nasseri, S.; McConnell, H. M. *Nature* **1989**, *337*, 274–276.
(3) Sette, A.; Southwood, S.; O'Sullivan, D.; Gaeta, F. C.; Sidney, J.; Grey, H. M. *J. Immunol.* **1992**, *148*, 844–851.
(4) Tampe, R.; McConnell, H. M. *Proc. Natl. Acad. Sci. U.S.A.* **1991**, *88*, 4661–4665.
(5) Witt, S. N.; McConnell, H. M. *Proc. Natl. Acad. Sci. U.S.A.* **1991**, *88*, 8164–8168.
(6) Witt, S. N.; McConnell, H. M. *J. Am. Chem. Soc.* **1992**, *114*, 3506–3511.
(7) Buus, S.; Sette, A.; Colon, S. M.; Grey, H. M. *Science* **1988**, *242*, 1045–1047.
(8) (a) Sadegh-Nasseri, S.; Germain, R. N. *Nature* **1991**, *353*, 167–170. (b) Stern, L. J.; Wiley, D. C. *Cell* **1992**, *68*, 465–477.
(9) Buus, S.; Sette, A.; Colon, S. M.; Miles, C.; Grey, H. M. *Science* **1987**, *235*, 1353–1358.
(10) Dornmair, K.; Clark, B. R.; McConnell, H. M. *FEBS Lett.* **1991**, *294*, 244–246.
(11) I-A^d was isolated using an MKD6 monoclonal antibody column as described.[12] The sample buffer and column buffer consisted of 10 mM sodium phosphate, 150 mM sodium chloride, 0.02% (w/v) sodium azide, and 1.0 mM dodecyl β-D-maltoside (Sigma).
(12) Viguier, M.; Dornmair, K.; Clark, B. R.; McConnell, H. M. *Proc. Natl. Acad. Sci. U.S.A.* **1990**, *88*, 7170–7174.
(13) Slow nonspecific binding of the $\alpha\beta$P* complexes to the wall of the sample tube would result in the slow loss of the $\alpha\beta$P* signal. However, the loss of the $\alpha\beta$P* signal in the gel filtration experiments is accompanied by a corresponding gain in the P* signal. The sum of the integrated intensities of the $\alpha\beta$P* and P* signals remains practically constant over the incubation period. Thus the loss of the $\alpha\beta$P* signal is not due to nonspecific loss of the protein.
(14) The dissociation kinetic experiments sometimes show a rapid initial decay phase (5–10 h) with a variable amplitude (10–30%). This initial decay phase is evidently due to an intermediate complex whose concentration, depending on the peptide used, is either enhanced or reduced at low temperature upon storage.
(15) One must consider the possibility that the dissociation kinetics correspond to the reaction $\alpha\beta P^* \rightarrow \alpha + \beta P$, or $\alpha P^* + \beta$, rather than reaction 2. The gel filtration column used can separate $\alpha\beta$P* complexes from the subunit–peptide complexes, and fluorescent subunit–peptide complexes were not detected, so the loss of the $\alpha\beta$P* signal is not due to this heterodimer splitting reaction. See also ref 6.

first there is an ~20% increase in the $\alpha\beta$P* fluorescence signal, followed by a slow, first-order decay. This increase in fluorescence signal intensity may be due to the transient increase in concentration of the $\{\alpha\beta P^*\}_o$ intermediate, assuming that this intermediate has a conformation such that the fluorescence quantum yield is larger than it is for $\{\alpha\beta P^*\}_c$.[16,17] Previous work[2] has provided evidence for a kinetic intermediate in the dissociation of FpCyt*c*(88-104) from I-E^k.

The activation energy ΔH^* for reaction 1 was estimated by studying the dissociation rates over the 20-40 °C temperature range and fitting the long time decay portion of the 20-30 °C biphasic curves to a single exponential. Our estimate is that $\Delta H^* = 10 \pm 3$ kcal/mol, with a frequency factor of 20 ± 4 s^{-1}.

To summarize, the thrust of the present letter is to argue that the equality of the kinetic off rates implies (at least) a two-step kinetic reaction mechanism (1-2), such that the rate-limiting step is peptide structure-independent. Of course, this argument does not imply that this result will be found with I-A^d and all other peptides, nor with other class II MHC-peptide combinations. Even so, it is probable that mechanism 1-2 will apply to most peptide dissociation reactions from class II MHC proteins.

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(16) This increase of fluorescence intensity might also arise if a population of molecules with the closed conformation contained two fluorescent peptides with fluorescence quenching. The loss of one fluorescent peptide in the open conformation would then lead to enhanced fluorescence per heterodimer. Energy transfer between a fluorescent peptide donor and a fluorescent peptide acceptor bound to a single MHC molecule has been reported.[17]

(17) Tampe, R.; Clark, B. R.; McConnell, H. M. *Science* **1991**, *254*, 87-89.

The Diosmium Tetrahydroxydisiloxane, $[OsCl(CO)(PPh_3)_2Si(OH)_2]_2O$, from the Coordinatively Unsaturated Trihydroxysilyl Complex, $Os(Si[OH]_3)Cl(CO)(PPh_3)_2$

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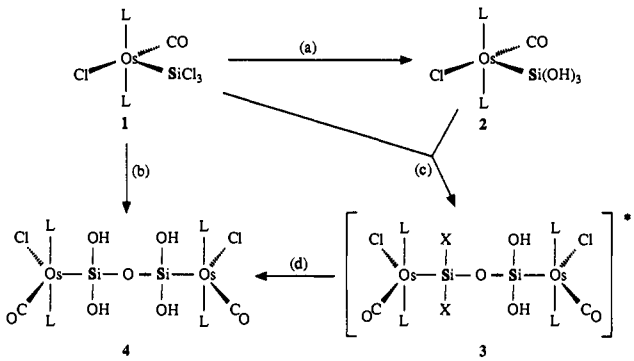
The hydrolysis of organotrichlorosilanes ($RSiCl_3$) typically leads to cross-linked polymeric siloxanes.[1] If the organo groups are large and carefully controlled conditions are employed, oligosilsesquioxanes[2] or even organosilanetriols[3] can sometimes be isolated. In contrast, the hydrolysis and condensation reactions of transition metal trichlorosilyl complexes (L_nMSiCl_3) have been much less studied.[4] In this communication we report the synthesis and structure of the first transition metal trihydroxysilyl complex[5] ($Os(Si[OH]_3)Cl(CO)(PPh_3)_2$, **2**) and the first dimetallo tetrahydroxydisiloxane[6] ($[OsCl(CO)(PPh_3)_2Si(OH)_2]_2O$, **4**), both of which can be obtained via hydrolysis of $Os(SiCl_3)Cl(CO)(PPh_3)_2$ (**1**).[7]

Scheme I[a]



[a] (a) 3 equiv of OH^- in THF/H_2O (high yield, 85%); (b) ca. 1 equiv of OH^- in THF/H_2O (low yield, <10%); (c) reaction of **1** with 1 equiv of compound **2** (high yield); (d) H_2O (high yield, 70% overall); L = PPh_3, X = Cl or OH, *postulated intermediate.

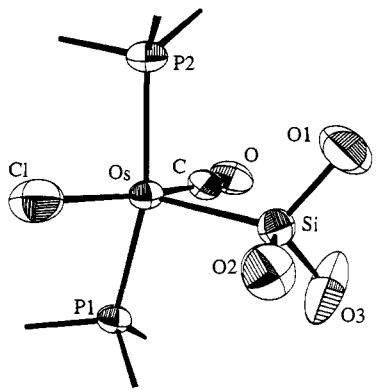


Figure 1. ORTEP view of **2** with the phenyl rings of the PPh_3 ligands omitted for clarity. Thermal ellipsoids at the 50% probability level. Important distances (Å) and angles (deg): Os-Si, 2.319 (2); Si-O(1), 1.647 (5); Si-O(2), 1.649 (5); Si-O(3), 1.624 (5); Si-Os-Cl, 104.6 (1); Si-Os-C, 86.4 (2).

Treatment of **1** with aqueous sodium hydroxide in tetrahydrofuran rapidly produces the yellow, coordinatively unsaturated trihydroxysilyl complex $Os(Si[OH]_3)Cl(CO)(PPh_3)_2$ (**2**) (ca. 85%) (Scheme I). New bands in the infrared spectrum of **2** at 3616, 828, and 777 cm^{-1} are assigned to the trihydroxysilyl group. A broad signal in the ^{1}H NMR spectrum at 2.38 ppm, which integrates for three protons and disappears on addition of D_2O, is assigned to the resonance of the $Si(OH)_3$ protons. Unambiguous characterization has been achieved by a single-crystal X-ray structure determination,[8] and an ORTEP diagram of **2** is shown in Figure 1.

The geometry about osmium is essentially square pyramidal with the silyl group in the apical position. The Os-Si bond length of 2.319 (2) Å is one of the shortest that has been reported,[9] and

(1) Aylett, B. J. *Organometallic Compounds, Vol. I, Part Two: Groups IV and V*, 4th ed.; Chapman and Hall: London, 1979; pp 1-130.

(2) See, for example: Feher, F. J.; Budzichowski, T. A.; Blanski, R. L.; Weller, K. J.; Ziller, J. W. *Organometallics* **1991**, *10*, 2526-2528. Agaskar, P. A. *Inorg. Chem.* **1991**, *30*, 2707-2708 and references therein.

(3) (a) Ishida, H.; Koenig, J. L.; Gardner, K. C. *J. Chem. Phys.* **1982**, *77*, 5748-5751. (b) Al-Juaid, S. S.; Buttrus, N. H.; Damja, R. I.; Derouiche, Y.; Eaborn, C.; Hitchcock, P. B.; Lickiss, P. D. *J. Organomet. Chem.* **1989**, *371*, 287-295.

(4) (a) Aylett, B. J. *Adv. Inorg. Chem. Radiochem.* **1982**, *25*, 1-133. (b) Mackay, K. M.; Nicholson, B. K. In *Comprehensive Organometallic Chemistry*; Wilkinson, G., Stone, F. G. A., Abel, E. W., Eds.; Pergamon Press: Oxford, 1982; Vol. 6, pp 1043-1114. (c) Glocking, F.; Houston, R. E. *J. Organomet. Chem.* **1973**, *50*, C31-C32.

(5) A monohydroxysilyl complex of platinum (formed by hydrolysis of an ortho-metalated phenylsilyl ligand) was recently reported: Chang, L. S.; Johnson, M. P.; Fink, M. J. *Organometallics* **1991**, *10*, 1219-1221.

(6) The dimetallo disiloxanes *trans*-$[PtX(PEt_3)_2(SiH_2)]_2O$ (X = Cl, Br, I) have been reported to form on reaction of *trans*-$PtHX(PEt_3)_2$ with the disiloxane $(SiH_3)_2O$: Ebsworth, E. A. V.; Edward, J. M.; Rankin, D. W. H. *J. Chem. Soc., Dalton Trans.* **1976**, 1667-1672. A cyclometallo disiloxane reportedly forms on hydrolysis of $Pt(SiCl_3)_2(PPh_3)_2$ (see ref 4c).

(7) Clark, G. R.; Rickard, C. E. F.; Roper, W. R.; Salter, D. M.; Wright, L. J. *Pure Appl. Chem.* **1990**, *62*, 1039-1042.

(8) Yellow crystals of **2** were grown by slow diffusion of *n*-hexane into a dichloromethane solution of **2** at 4 °C. Crystal data: $a = 13.664$ (3), $b = 12.355$ (2), $c = 20.278$ (4) Å, $\beta = 95.50$ (2)°, $Z = 4$, d(calcd) = 1.670 g cm^{-3}, space group $P2_1/c$. A total of 5290 reflections ($I > 3\sigma(I)$) were collected on a Nonius CAD-4 diffractometer at 293 K using Mo Kα radiation (λ = 0.71069 Å). Least-squares refinement converged to $R(F) = 0.037$ and $R_w(F) = 0.042$.

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